SOUTHSHORE INDUSTRIAL AREA
AREA OF PARTICULAR CONCERN
(APC)

A COMPREHENSIVE ANALYTIC STUDY

V.I. DEPARTMENT OF PLANNING AND NATURAL RESOURCES
Coastal Zone Management Program

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LIST OF KEY ACRONYMS

Area of Particular Concern	APC
Base Flood Elevation	BFE
Coastal Barriers Resource System	CBRS
Coastal Zone Management Act	CZMA
Department of Planning and Natural Resources	DPNR
Department of Public Works	DPW
Division of Coastal Zone Management	CZMP
Division of Environmental Enforcement	DEE
Division of Environmental Protection	DEP
Division of Fish and Wildlife	DFW
Federal Emergency Management Agency	FEMA
Hess Oil Virgin Islands Corporation	HOVIC
Mean High Water	MHW
Mean Low Water	MLW
Million Gallons Per Day	MGD
National Ambient Air Quality Standards	NAQS
National Flood Insurance Program	NFIP
Sewage Treatment Plant	STP
Significant Natural Area	SNA
Territorial Pollutant Discharge Elimination System	TPDES
U.S. Army Corps of Engineers	USACOE
U.S. Environmental Protection Agency	USEPA
U.S. Fish and Wildlife Service	USFWS
U.S. Geological Survey	USGS
University of the Virgin Islands	UVI
Virgin Islands Alumina Corporation	VIALCO
Virgin Islands Rum Industries, Ltd.	VIRIL
Water and Power Authority	WAPA

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I. INTRODUCTION

1.1 General

The Southshore Industrial Area is one of 18 Areas of Particular Concern (APC's) designated by the Planning Office in 1979 after public nominations and comment had been received (Figure 1). It is located approximately mid-way along St. Croix's south shore, and about three miles across island from Christiansted. It extends from Canegarden Bay to Betty's Hope at the west end of Manning Bay, southwest of Alexander Hamilton Airport (Figure 2). The shoreline and inland areas are the most heavily developed and altered coastal areas in the Territory. An extensive mangrove lagoon was filled with dredge material in the 1960's to create land for the numerous industries which today employ several thousand people.

On July 26th 1991, the CZM Commission adopted the 18 APC's recommended in the Final Environmental Impact Statement (USDOC 1979), which accompanies the Virgin Islands CZM Act. The Final Environmental Impact Statement notes "the importance of the entire coastal zone" but declares that "certain areas are of yet greater significance." It also establishes the criteria for the designation of Areas of Particular Concern which are as follows:

- Significant Natural Areas
- Culturally Important Areas
- Recreation Areas
- Prime Industrial and Commercial Areas
- Developed Areas
- Hazard Areas
- Mineral Resource Areas

In September of 1991, the Coastal Zone Management (CZM) Commission met and held public hearings on all three islands on the boundaries for all 18 APC's. The Commission met again on October 1, 1991 and, based upon public input and staff recommendations, approved the boundaries of the APC's.

APC management requires knowledge of an area's historical development and traditional uses, and an action-oriented plan for the area's future utilization. This Study and proposed management plan is intended to serve as the overall planning and management framework within which the various regulatory entities carry out their respective decision-making authorities.

The APC planning effort recognizes that permit decision-making is most often reactive; that is, the decision to approve or disapprove a proposed development is made in response to a permit request, not in advance of it. The general goal of developing an APC management framework is to be able to make *a priori* decisions about the allowable extent of modification of an entire landscape unit. In other words, to raise the level of decision-making from the site-specific to that of natural landscape units and the maintenance of a wide array of interactive resource uses.

1.2 Relationship to Other Plans and Regulations

The Southshore Industrial Area APC Comprehensive Analytic Study and proposed management plan were prepared under the authority of the Coastal Zone Management Commission. The Study and proposed Plan is intended to serve as the overall planning and management framework within which the various planning and regulatory entities carry out their respective authorities. It is intended that the policy framework contained herein be incorporated into the policies and review criteria of those entities, including, but not limited to, the Department of Planning and Natural Resources (DPNR), the Department of Housing, Parks and Recreation (DHPR), the Port Authority, the Water and Power Authority (WAPA), the Department of Public Works (DPW), the National Park Service (NPS), the U.S. Fish and Wildlife Service (USFWS), the U.S. Army Corps of Engineers (USACOE), the U.S. Environmental Protection Agency (USEPA), and the Department of Property and Procurement. This Study and proposed Plan will serve as a guide for future decisions concerning the area. Future development activity should be consistent with the Study and proposed plan.

The intent of this Comprehensive Analytic Study and proposed management plan is for all participating territorial and federal agencies to utilize the broad policy framework to guide planning and permit decisions with respect to their own authorities. For those agencies that issue permits or review and comment on permit applications, the Study and proposed plan does not eliminate the authority of those agencies, but increases the predictability and timeliness of the permitting process since many of the issues that must be addressed in a specific permit application are already addressed in the Study and proposed management plan.

The issues surrounding any proposed use or activity within the coastal environment are complex. A proposed use immediately outside the boundary of the APC planning area may result in significant adverse impacts on the APC and impair the goals of the APC management framework described herein. This Plan contains several different forms of guidance, all of which should be considered in evaluating impact on an APC. Both the individual property owner who is considering a specific proposal and the decision-maker who is evaluating the proposal should follow the guidance of this Plan.

1.3 Historical Perspective and Overview

The Southshore Industrial Area is the Territory's most significant industrial complex in terms of size, capital investment, and importance to the local and territorial economies. At one time, the area comprised the Territory's largest mangrove lagoon (Krause Lagoon), which was an important nursery for a diversity of aquatic and wildlife species (Figure 3). The destruction of the lagoon brought irreversible environmental change, as well as the demise of local fisheries productivity. Nevertheless, several coastal and offshore areas continue today to provide valuable habitat, including mangroves, seagrass beds, and an offshore dredge-spoil islet, which has become refuge for a variety of wildlife. The area thus continues to support important socioeconomic and biological functions, and is worthy of special planning efforts as an Area of Particular Concern.

Prior to European arrival, the APC watershed was covered with native vegetation which, in combination with thick stands of mangroves, served to filter and cleanse runoff waters before reaching the ocean. During the plantation era, these forests were converted to agricultural plots, and as a result the

plant and animal communities in the area today are considerably altered from their indigenous, native habitat conditions.

The heavy industrial use of the area is the source of considerable environmental stress. Among the most serious existing and potential environmental impacts that must be addressed are those associated with the loss or degradation of water quality. With the largest oil refinery in the western hemisphere (the Hess Oil Virgin Islands Corporation, or HOVIC) operating within the APC, the potential is high for a major oil spill to occur along the southshore.

Of 15 sites listed nationally as "high volume ports", the HOVIC port is number four. The sheer volume of petroleum products transported through the area is immense, and production capability for refined oil is on the order of 545,000 barrels per day (USVI Govt/DPNR, 1991). [Note: average daily production is on the order of 300,000 barrels per day (HOVIC, 1993).] Supertankers carry crude oil to the HOVIC port, with capacities up to 185,000 Dead Weight Tonnage. Such high volumes of oil, coupled with the hurricane and collision potential which exists at the heavily used southshore area, raise concerns about the risk of a major oil spill.

The HOVIC port terminal is well-equipped with oil booms, absorbents, skimmers, vacuum trucks, storage tanks, and barges to cope with almost any marine oil spill emergency. Moreover, oil spill response capability is undergoing further improvements with the establishment of a private-sector "cooperative" that will strive to meet new regulations required under the Oil Pollution Act of 1990.

While a major oil spill is a **potential** impact to the Southshore Industrial Area, several outfalls **regularly** discharge treated effluent or untreated stormwater effluent to the nearshore waters. A major bauxite processing plant (the Virgin Islands Alumina Corporation, or VIALCO) operates in the area, discharging treated "processed water" through a series of cooling ponds. Suspended solids comprised of trace heavy metals and a filamentous blue-green algae, are unintentionally but continuously discharged into the marine environment at Alucroix Channel. Other discharge sources are the sewage outfall at the St. Croix Municipal Sewage Treatment Plant; a waste outfall at the Virgin Islands Rum Industries Ltd (VIRIL) distillery; a main outfall at the HOVIC facility (which discharges treated stormwater and oily wastewater); and stormwater discharges through several guts and drainage channels throughout the area.

The alteration of the area's natural drainage patterns imposes stress on the nearshore environment. Coastal wetlands depend on freshwater supplies from surface runoff. In several areas these supplies have been restricted or eliminated by development. Moreover, runoff discharged at the coastline is now a concentrated pulse of freshwater, carrying increased levels of sediments and other contaminants from the developing watershed. These nonpoint pollution sources, when added to the several different types of point source discharges (i.e., outfalls which carry industrial chemical and thermal wastes, or sewage plant effluent), introduce considerable loading stress to the nearshore environment.

Thus, it is important that a management framework recognize the totality of the system, including the impacts which watershed development (upslope from the APC) will have on the nearshore marine environment. In this regard, despite the "official" boundaries of the APC, the entire watershed must be considered as integral to the planning area, and the use of Best Management Practices required if effective environmental management is to be achieved.

In addition, a significant contributor to poor water quality in the area are the sediments stirred up from ship propeller wash. Sedimentation impacts have altered the type and structure of benthic communities able to survive in the vicinity of shipping channels and down current areas.

Groundwater quality, although not fully assessed for the entire APC and adjacent areas, has suffered declines in certain known areas. Oil has leaked or spilled onto the ground over the course of several years at the HOVIC refinery, and a spilled hydrocarbon (oil) recovery program has been underway since 1982. The exact dimensions of the problem are not fully clear, but HOVIC reports that as much as 415,900 barrels have already been recovered, and at least another 221,150 barrels (or approximately 10 million gallons) are known to remain in the ground (HOVIC, 1992). HOVIC is working closely with the USEPA on the problem and has spent significant sums of money to date to effect recovery and prevention of further contamination. Although HOVIC data thus far indicate that hydrocarbon contamination has not undergone subsurface migration beyond the refinery's boundaries, groundwater contamination of this magnitude, especially on the edge of the largest aquifer on St. Croix (the Kingshill aquifer), is deserving of priority attention.

Likewise, air quality is of concern for at least some residents of adjacent, downwind communities. Stack emissions by the major industries are significant, and additional emissions from the many smaller industries and businesses in the area cannot be ignored. The cumulative impacts of stack discharges from all sources should be assessed and evaluated against agreed upon standards for the entire area.

1.4 Other Classifications

Two sites within the APC are included in the Federal Coastal Barrier Resources System (CBRS): (1) Canegarden Bay (site VI-08); and (2) Krause Lagoon, a good shorebird habitat consisting of mudflats and mangroves (site VI-09) [Figure 4]. The Federal Coastal Barrier Improvement Act of 1990 established areas in the USVI as part of the CBRS. The purpose of the system is threefold (IRF, 1986):

1. To halt development in low-lying areas subject to natural disasters (i.e., flooding, hurricanes, etc.);
2. To stop wasteful federal expenditures in these areas; and
3. To protect valuable natural resources from being destroyed by unwise economic development.

The entire shoreline of the APC is situated within a designated 100-year floodplain (section 2.3.3) [Figures 5a and 5b].

Prior to infilling to create the industrial area, Krause Lagoon was nominated as the 'Krause Lagoon Wildlife Refuge' (USDOI, 1960). This "game reserve" administered by the V.I. Department of Public Safety was at that time the best territorial example of a marsh-lagoon ecosystem, and comprised approximately 200 acres of the northwest quarter of Krause Lagoon. Considerable dumping of solid waste, however, was apparently common and widespread.

With the adoption of the territorial Coastal Zone Management Program in 1979, several sites within the APC were identified as potential Significant Natural Areas (SNA's), including the following (Figure 6):

Manning Bay - the last relatively pristine mangrove lagoon on St. Croix's southshore and refuge for endangered species; threatened by various developments, including the nearby Anguilla solid waste landfill and sewage treatment plant; area includes a major drainage gut that is refuge for brackish aquatic species, and large turtle seagrass beds offshore; V.I. Government owned.

Ruth Cay - a refuge for the transplanted, endangered St. Croix Ground Lizard *(Ameiva polyps)*; the only known nesting site in the USVI for the White-crowned Pigeon *(Columba leucocephala)* post-Hurricane Hugo [pers. comm., B. Knowles, DPNR/DFW]; V.I. Government owned.

VIALCO Pond and Mangroves - a surviving remnant of Krause Lagoon; diverse habitat for aquatic and wildlife species; the area is today significantly altered, although the potential exists in several areas for mangrove restoration.

VIALCO Eastern Wetlands/Salt Flats - hydrology has been significantly altered; the area is more arid today and denuded of vegetation in parts (pers. comm., A. Dempsey, Bioimpact); location of a significant stand of Black Mangrove *(Aviccenia germinans)*.
s at Canegarden Bay - also known as Cassava Gardens Ponds or VIRCO Ponds; formerly reported as the best breeding site in the Territory for the endangered Least Tern *(Sterna albifrons);* currently owned and managed by the University of the Virgin Islands.
Low Shoreline Cliffs East of Billy French Ponds - one of the few White-tailed Tropicbird *(Phaethon lepturus)* nesting sites in the U.S. Virgin Islands and British Virgin Islands (pers. comm., D. Nellis, DPNR/DFW).

An effort to survey and describe the major biological attributes of SNA's was initiated in 1989 by the DPNR/DCZM. However, the project was terminated prior to completion, and as yet no official designation of SNA sites has occurred.

Finally, the V.I. Code (Title 12, Chapter 1, Section 94) authorizes the Commissioner of DPNR to manage and regulate all uninhabited, government-owned cays and islets in the U.S. Virgin Islands and to designate wildlife refuges. Thus, Ruth Cay is subject to DPNR management and is the focus for appropriate attention by DPNR/DFW officials (section 2.4.1).

2. DESCRIPTION OF THE SITE

2.1 APC Boundary

The boundary for the Southshore Industrial Area APC, established by the Coastal Zone Management Commission in October 1991, is described as follows (Figure 2):

Beginning at a point on the shoreline of Canegarden Bay defined by the extension of the north-south section of Route 62, the boundary extends in a straight line north-northwest along Route 62 to the

intersection of Route 62 and Route 68, then westerly along Route 68 to a point where Route 68 turns northerly; then northerly along Route 68 one-thousand-four-hundred (1400) feet (following the CZM Tier 1 boundary) to Route 709; then continuing northerly along Route 709 to the intersection of Route 709 and Route 66 (Melvin Evans Highway); then westerly along Route 66 to where Route 66 intersects with Route 64 (Airport road); then south and then westerly along Route 64 to a dirt road west of the Texaco storage tank farm; then south on that dirt road to the shoreline; then due south to the outer shelf edge or the three mile limit (whichever is closer); then easterly along the outer shelf edge or three mile limit to a point due south of the point of origin; then due north to the point of origin in Canegarden Bay (USVI Govt/DPNR, 1992a).

2.2 Ownership Summary

Within the APC boundary, land ownership is both private and public. The major corporations owning land are HOVIC (Hess Oil Virgin Islands Corporation) and VIALCO (Virgin Islands Alumina Corporation, formerly Martin Marietta). The USVI Government owns several public infrastructure facilities, including those operated by the Department of Public Works (a sewage treatment plant and a solid waste landfill) and the Water and Power Authority (a proposed 22 megawatt power plant). In addition to the Alexander Hamilton Airport, a portion of which falls within the APC, the Port Authority operates a bulk cargo port with container handling and roll-on/roll-off facilities, as well as a bulk-liquid cargo dock which supports deliveries to the rum distilleries operating on the island. One of these, the Virgin Islands Rum Industries, Ltd. (VIRIL) rum distillery, is located west of the Alexander Hamilton Airport. Its waste outfall discharges within the APC boundary (see Figure 12a).

The University of the Virgin Islands (UVI) owns the Billy French Ponds located east of HOVIC; a management plan for the ponds is currently being prepared by the University.

Within the watershed, considerable residential development exists, as do a number of public and private commercial concerns. Residential land uses include public housing projects, approved subdivisions, and scattered individual homes. Several Government offices are located here, as is the University of the Virgin Islands St. Croix campus, a public hospital, and an adult correctional facility. The majority of commercial businesses are clustered around three shopping centers: the Villa La Reine; Sunny Isle; and Sion Farm Shopping Center. Other businesses are located along the main roads and include all types of service and retail operations which support the local populace.

A horse racetrack and stables are located within the APC immediately south of the airport.

2.3 Physical Environment

2.3.1 Climate

Rainfall in the Virgin Islands generally increases with increasing elevation and exhibits a trend on each island of a dry-to-wet cline from east to west. Average rainfall data can be misleading because of the high geographic and seasonal variability. The U.S. Virgin Islands receive an average of 41 inches of rain per year (Bowden, 1968).

The wettest months are September to December, and the dry season is February to July for St. Croix. Most of St. Croix, including the Southshore Industrial Area, receives 35-45 (average about 40) inches of rainfall per year. The northeast hills receive slightly more, and Annaly, the wettest area, receives an average of 52 inches per year (Bowden, 1970). Rainfall usually occurs in brief, intense showers of less than a few tenths of an inch.

Temperatures average an annual 79° degrees Fahrenheit, with temperatures in the winter averaging 76° degrees F and in the summer averaging 84° degrees F.

The Virgin Islands lie in the "easterlies" or "trade winds" which traverse the southern part of the "Bermuda" high pressure area; predominant winds are thus from the east-northeast and east (IRF, 1977). These trade winds vary seasonally, but most significantly during the late summer months when tropical depressions may form resulting in storms and/or hurricanes. Hurricane season is from June to November, with peak activity occurring in September. The annual probability of a hurricane is once every 16 years (Bowden, 1974).

2.3.2 Geological Setting

St. Croix was formed from volcanic sediments deposited deep on the ocean floor in the late Cretaceous period (approximately 80 million years ago). The rocks which underlie the mountain ranges are sedimentary, formed by debris from eroding volcanic rocks (Whetten, 1974). Two predominant mountain ranges exist (the Northside Range and East End Range), separated by a central sediment-filled valley. At one time, the two ranges were distinct islands, separated by a submerged lagoonal environment, which during a later period of uplifting formed the present sediment-filled valley and island of St. Croix. The rock underlying the Southshore Industrial Area is comprised primarily of Kingshill Limestone deposits (Rees and Associates, 1991).

Prior to the dredging of Krause Lagoon in 1965, the area was classified as Tidal Swamp and Tidal Flats. Today, the area is primarily man-made with a layer of hydraulically dredged marine sand overlying an average 20-foot layer of loose silt (former swamp material, now compressed). This is further underlain by 60-100 feet of mottled clay with shells and coral, and a deeper layer of marl with silty clay, sand, and coal at the 100-foot depth (Rees and Associates, 1991). There are five major natural soil types found within the original fastland areas of the APC (USDA, 1970):
Anguilita Gravelly Clay Loam, 5-12 percent slopes, eroded (AgC2). This soil type is found around some portions of Limetree Bay and Canegarden Bay. This soil is not suitable for crops; it is shallow with poor water holding capacity. It has moderate limitations for highways, airports, and light industrial buildings, and only a slight limitation for trafficways and for residences which have community sewerage systems.

Augirre Clay, 0-2 percent slopes (AuA). Within the APC this soil type is found near the racetrack. This soil is sticky and hard to cultivate. It is limited for farm use due to its slow permeability, waterlogging, and poor workability. It is severely limited for all other uses due to its high shrink-swell potential, slow permeability, high plasticity, and poor load-bearing strength.

Cornhill Gravelly Clay Loam, 0-2 percent slopes (CoA). This soil is generally found on terraces and alluvial fans in the southern part of St. Croix and is found in areas around the Anguilla dump and

portions of the former Krause Lagoon (e.g., north of HOVIC property). It is severely limited for residential and light industrial use due to shrinking and swelling of the underlying plastic clay. It has moderate to severe limitations for recreational uses, campsites, picnic areas, intensive play areas, and golf fairways.

Hesselberg Clay, 0-2 percent slopes (HeA). Found in the southern and southwestern parts of St. Croix, including areas around Canegarden Bay. This soil is used mainly for row crops and grassland. It has limited farm use due to its shallowness over rock, and is severely limited for residential and light industrial use.

Leveled Marly Land (Lm). This soil is found near VIALCO and the Airport. It is composed of leveled and reworked Anguilita and Sion soils and has no value for farming. It has moderate limitations for trafficways, and severe limitations for residential and light industrial use due to its low load-bearing strength., It is moderately to severely limited for recreational use due to its stoniness and coarse fragments.

Historical seismicity in the USVI

As a result of convergence between the Caribbean and North American tectonic plates, the Virgin Islands are located in one of the most earthquake prone regions of the world. During the past 450 years, damage has occurred from earthquakes and associated tsunamis. Destructive tsunamis occurred in the U.S. Virgin Islands in 1867 and in 1918; the latter resulted in 116 deaths and economic losses estimated at $4 million (in 1918 dollars) [USGS, 1984].

Potential human and economic losses for a similar event occurring today would be several orders of magnitude higher. Scientists report high seismic potential for a major fault rupture in the Puerto Rico Trench north of Puerto Rico and the Virgin Islands (USGS, 1984). Seismic hazards to the built environment can be ameliorated with appropriate siting and design criteria.

2.3.3 Hydrological Setting

The APC receives drainage from the largest watershed on St. Croix, which is comprised of six sub-basins totalling nearly 12,000 acres (BC&E/CH_2M Hill, 1979) [Figure 7]. The largest of these encompasses nearly 7,000 acres and services the Kingshill aquifer (see below) which is utilized by a number of commercial and government wells (USVI Govt/DCCA, 1985).

Prior to intensive development of the watershed, the major drainages emptied into Krause Lagoon. When the lagoon was later filled as the site for the industrial area, drainage channels were built to convey runoff waters directly to the ocean. Today, Bethlehem Gut, which services the major 7,000 acre basin, is the only major drainage gut within the APC which discharges along its natural course directly into the ocean at the western edge of the former Krause Lagoon (west of VIALCO and east of the airport). The lower reach of the gut remains today in a relatively natural state and is heavily vegetated with Red Mangroves.

Altered drainage channels convey runoff waters at greater velocity and are themselves subject to erosion. Sediments and other contaminants from the watersheds are discharged to the ocean. The presence of barrier islands immediately offshore inhibits flushing of nearshore waters, resulting in increased turbidity for longer periods of time following heavy rain.

Strawberry Hill, La Reine, and Spanish Town make up a 2,087 acre basin that drains into the central portion of the APC. The runoff flows through the HOVIC west refinery in a concrete-lined canal (which also accepts runoff from the refinery), and then through a pair of culverts under the Container-port road, down another short channel, and then into a floodplain on the major portion of Estate Blessing. The runoff to the ocean is through a Black Mangrove swamp to the south and five culverts through a raised bank which lies parallel to the beach (Prince-Tams Joint Venture, 1984).

Both A-Zone and V-Zone floodplains exist within the APC. V-Zones are areas of 100-year coastal flood activity with velocity (wave) action, within which base flood elevations (BFE) are determined. Virtually the entire shoreline within the APC is within the V-Zone, with BFE of 6 feet (FEMA, 1987a and 1987b). A-Zones are, in general, comprised of 100-year riverine floodplains. In only some cases have BFEs and flood hazard ratings within A-Zones been determined for the area.

Groundwater provides approximately 30 percent of the potable water distributed through the public system on St. Croix (pers. comm., K. Thomas, WAPA). Presently, WAPA has the capacity to supply 1 MGD of well water and 2.3 MGD of desalinated water. Supplies are not enough to meet demand, and periodic rationing is necessary (pers. comm., K. Thomas, WAPA). A new 1.3 MGD desalination plant will become operational at Richmond in mid-1993 (pers. comm., K. Thomas, WAPA).

The principal groundwater aquifer on St. Croix underlies the central portion of the island within the APC watershed (Figure 16). The aquifer is known as the Kingshill Aquifer, and extends from the north-central coast to the southwest coast of the island. Groundwater withdrawals have increased from about 0.05 to 0.8 MGD since the early 1960's. Various modeling of the Kingshill aquifer has been carried out, indicating that withdrawal rates can be increased by 10%-30% with the addition of new recharge sources (e.g., construction of surface retention basins). On the other hand, without such improvements to total recharge rates, an increase in water discharge (pumping) rates in excess of 1.20 MGD could substantially lower the potentiometric surface and, thus, induce saline water intrusion (Torres-Gonzalez, 1990).

St. Croix has the greatest potential in the Territory for groundwater use due to its larger land area, less steep topography, and landforms which enhance recharge rates (CH_2M Hill Southeast, 1983). Most groundwater suffers poor quality, however, due to chlorides, sodium salts, and total dissolved solids (TDS) concentrations in excess of USEPA drinking water standards. Several hundred wells are privately owned in addition to the 200 or so public and industrial wells in use.

WAPA has negotiated with VIALCO to purchase excess desalinated water (approximately 1 MGD) to augment public supplies. An agreement has been reached, but awaits signatures of both parties (pers. comm., K. Thomas, WAPA).

2.3.4 Coastal Environment

Since the early formation of St. Croix, geologic activity has resulted in alterations to the coastline, including erosion of sediments and the formation of brackish ponds, beaches, reefs, and beach-rock. These geologic processes continue to shape the coastline. Within the APC, rocky shorelines alternate with sandy shorelines, and rocky shoreline cliffs occur east of Billy French Ponds in Canegarden Bay (Figures 8a and 8b). As indicated above, the most significant alterations to the coastal environment

occurred in the mid-1960's when the former Krause Lagoon was filled to create new land for the industrial area.

Offshore currents in the area move predominantly westward at less than 1.1 knots. Inshore currents are primarily wind and wave-driven, with tides appearing to have only minor effect on circulation patterns. Tides along the southern coast of St. Croix are normally less than one foot, with extreme high water at about 1.1-foot above MHW, and extreme low water at about 0.8-foot below MLW. Water levels can increase, however, to 7-feet above MHW due to storm surge activity (Prince-Tams Joint Venture, 1984). Storm surge levels during Hurricane Hugo were (unofficially) reported to exceed the 7-foot mark.

2.4 Biological Environment

2.4.1 Terrestrial

Remnant mangrove communities are scattered throughout the APC, especially along the shoreline from Manning Bay to Alucroix Channel (also known as Harvey Channel, Krause Lagoon Channel, and Martin Marietta Channel). Both Red Mangrove *(Rhizophora mangle)* and Black Mangrove *(Aviccenia germinans)* inhabit the shoreline's brackish waters. One of the more significant wetland communities exists within the lower reaches of Bethlehem Gut adjacent to Estate Anguilla. A series of ox-bow ponds has formed and the gut discharges to the ocean at a broad delta vegetated by an extensive Red Mangrove community.

Mangroves are common in the area of Alucroix Channel, extending westward along the shoreline for some 3000-4000 feet to the Anguilla landfill. This area was formerly the western half of Krause Lagoon. The dike between the VIALCO cooling ponds and the shoreline is vegetated with mixed plant communities, including mangroves, and provides good habitat for a number of wildlife species. Mangroves in this area have suffered declines, however, through both sedimentation and altered hydrology (pers. comm., B. Knowles, DPNR/DFW).

Another diked area on the northeast section of VIALCO's eastern salt flats (also known as "Area C") is heavily vegetated with Black Mangroves. This could be a potential source of transplanting material (seedlings) for future compensatory mitigation or wetland creation projects.

Philibosian and Yntema (1977) calculate that 90% of the resident and migrant bird species in the USVI are wetland-dependent.

Ruth Cay, lying offshore from the entrance to Alucroix Channel, was created by dredge-spoils during the 1965 filling of Krause Lagoon (Figure 8b). The Cay is today a refuge for the federally listed endangered St. Croix Ground Lizard *(Ameiva polyps)*. Ten immature ground lizards were introduced by DPNR/DFW officials in the early 1990's. Moreover, Ruth Cay, at least under present, post-Hugo conditions, is the only nesting site for the White-crowned Pigeon *(Columba leucocephala)* in the U.S. Virgin Islands. The White-crowned Pigeon prefers to nest in mature Red Mangroves, most of which along the south shore were destroyed during Hurricane Hugo. Since Hurricane Hugo, the pigeons have been reported to be nesting in high numbers at Ruth Cay, where presumably they feel less threatened by predatory cats, mongooses, and by hunting. Approximately 500 breeding pairs have

been reported (pers. comm., D. Nellis, DPNR/DFW). The Least Tern *(Sterna albifrons)* is found nesting on Ruth Cay in high numbers, and has also been reported to nest on HOVIC property and on the shoreline south of the VIALCO cooling ponds (pers. comm., B. Knowles, DPNR/DFW).

Despite the protection offered from predators, the Cay is a vulnerable habitat. Storm surge and heavy swells are gradually eroding the island (pers. comm., D. Nellis, DPNR/DFW). Moreover, this in turn causes turbidity and sedimentation, a problem for the corals and seagrasses found nearby.

The Billy French Ponds at Canegarden Bay consist of two ponds with a total area of 8.4 acres (Knowles and Amrani, 1991). The ponds are located on 52 acres of land owned by UVI and managed by its Eastern Caribbean Center. The UVI Foundation recently received a grant from Leon Hess of HOVIC to undertake specific management actions at the Ponds during the next five years.

The ponds are classified as one of nine major wetland areas on St. Croix. Because of the unique biogeographical position of the U.S. Virgin Islands, lying halfway between North and South America, the islands are along the annual migratory routes of several bird species. The Billy French Ponds and associated mudflats provide resting and foraging habitat for these migratory birds. Of the 84 bird species that have been recorded for the area, 23 are federally or locally listed as endangered or threatened, while 8 are believed to use the ponds as breeding habitat (UVI, in press). The ponds have not dried up for several years, and salinity levels are reported to fluctuate relatively little, indicating that the ponds are serviced by an underground water source. The ponds are an important refuge for herons and egrets, as well as various waterfowl, including the locally endangered Bahama Duck *(Anas bahamensis)*. The locally endangered Roseate Tern *(Sterna dougallii)* is also reported to occasionally feed at the ponds (pers. comm., B. Knowles, DPNR/DFW).

The ponds are man-made, converted from former swamp lands during the creation of the HOVIC site in the 1960's. Water flows between the ponds during flood periods; otherwise the ponds are separated by a grass and shrub vegetated berm. The eastern pond is comprised largely of Black Mangrove (canopy height 4-6 meters), with grass and casha *(Acacia spp.)* bordering the pond, changing to upland vegetation to the north. A residential access road along the east side of the pond has altered the hydrology in the area, despite (unsuccessful) efforts to install a culvert. One result is that habitat for wading shorebirds is lost where the water depth now exceeds 35 cm (pers. comm., F. Schaffner, USFWS).

The western pond is heavily influenced by freshwater inflows from the Fig Tree Hill Gut, with the result that water levels fluctuate more than in the eastern pond. Sewage bypass flows from the nearby Fig Tree pump station are not uncommon in the gut, which also receives stormwater runoff at two discharge points on HOVIC property. [Note: During bypass operations, HOVIC is known to pump sea water into the gut to ameliorate the odors emanating from the gut.] DPNR allows HOVIC to discharge from these two stormwater outfalls; oil and water separators are utilized. The pond is bordered by a road to the west, and the beach immediately to the south. Black Mangroves comprise some 10% of the pond area (compared with some 60% for the eastern pond); canopy height is less at between 2-3 meters (Knowles and Amrani, 1991).

A massive fish kill occurred at the Billy French Ponds in January 1992 due to sewage bypass from the Fig Tree pump station. DPNR/DFW officials estimated that in excess of 6,900 fish *(Tilapia spp.,*

Gambusia spp., and *Megalops atlantica)* from the ponds were killed due to the increased biological oxygen demand (BOD) of the wastewater entering the ponds.

Rare or endangered avifauna reported to utilize the Billy French Ponds include: Brown Pelican *(Pelecanus occidentalis)*, Great Blue Heron *(Ardea herodias)*, Bahama Duck *(Anas bahamensis)*, Least Bittern *(Ixobrychus exilis)*, White-tailed Tropicbird *(Phaethon lepturus)*, Peregrine Falcon *(Falco peregrinus)*, Great Egret *(Casmerodius albus)*, Black-crowned Night Heron *(Nycticorax)*, Caribbean Coot *(Fulica caribea)*, and the Least Tern *(Sterna albifrons)* (Weston, Inc. 1974; pers. comm., B. Knowles, DPNR/DFW). The Fisherman Bat *(Noctilio leporinus)*, a nocturnal piscivorous mammal, is found along this stretch of coast and probably also utilizes the ponds.

Avifauna reported to occur at other various locations within the APC include: Brown Pelican, Brown Booby, Wilson's Plover, Willet, American Oystercatcher, Osprey, Peregrine Falcon, Least Tern, Royal Tern, Black-billed Plover, Semipalmated Sandpiper, Ruddy Turnstone, Spotted Sandpiper, Lesser Yellowlegs, Stilt Sandpiper, and the Black-necked Stilt (Strategic Planning Group, 1991). The above lists of wildlife frequenting the Southshore Industrial Area are likely not complete.

2.4.2 Marine

Several environmental assessment reports have described the marine and terrestrial environments of the Southshore Industrial Area (Rees and Associates, 1991; Bioimpact, 1991; Weston, 1974; Banus, *et al.*, 1977; Insular Environments, 1975; Howard Needles Tammen & Bergendoff, 1975). The following descriptions are a synthesis of information contained in the reports, and refer largely to the area offshore of the HOVIC and VIALCO properties.

Marine environments are dynamic and present few of the barriers to species dispersal as exist on land. Nevertheless, a combination of factors -- substrate type, currents, depths, water clarity, temperature, oxygen, salinity, and available nutrients -- to name a few, determine the structure and composition of benthic communities and associated fish populations.

Several species of seagrasses colonize the offshore waters, including "turtle grass" *(Thalassia testudinum)*, "manatee grass" *(Syringodium filliforme)*, and "shoal grass" *(Halodule wrightii)*. Generally one of these species is dominant in a given area, although all three, and other species, are found in association elsewhere. As water depth and clarity increases, *T. testudinum* and *S. filliforme* predominate.

Where hard substrate is available, red and brown algae grow, otherwise calcareous green algae is found in sandy, mucky areas. Shallow water algal growth consists of several genera, including: *Halimeda, Penicillus, Valonia, Galaxaura, Caulerpa, Turbinaria, Dictyopteris, Wrangelia, Bryopsis, Hypea, Spyridia,* and *Ulva.* These lists of seagrasses and algae are only representative; they are not complete.

Where mangroves exist, juvenile fishes and invertebrates take refuge in their prop roots, which are themselves encrusted by various algae, sponges, and occasionally mangrove oysters. Fish data is not extensive, although Dusky Damsels *(Pomacentrus fuscus)*, anchovies *(Anchoa spp.)*, Barracuda

(Syphyraena barracuda), Cocoa Damselfish *(Eupomacentrus variabilis),* and Sergeant Major *(Adudefduf saxatilis)* are reported. Other marine fauna reported along the entire southshore of St. Croix include various species of snapper, grouper, grunt, and spiny lobster, as well as Queen Conch and the West Indian Topshell (Strategic Planning Group, 1991; Prince-Tams Joint Venture, 1984). Other fish species no doubt utilize the area as well.

As part of compensatory mitigation requirements for the creation of new landfill at the liquid bulk terminal on the east side of Alucroix Channel (section 3.1), the U.S. Army Corps of Engineers required that Port Authority transplant seagrasses from the dredge area to a receiving area offshore of Ruth Cay. The transplants were carried out in 1987. Three species were transplanted: "turtle grass" *(Thalassia testudinum),* "shoalgrass" *(Halodule wrightii),* and "manatee grass" *(Syringodium filiforme).* Significant portions of the transplants survived the effects of Hurricane Hugo and were found to be alive and healthy when last monitored in 1990 (Coulston, 1990).

Remaining coral reefs in the area are mostly silted over and dead. Dredging, fill, turbidity, and sedimentation have taken their toll on coral reefs. Beginning with the area in Manning Bay south of the airport, small patch reefs occur along the south coast and merge with the extensive reef formations of the southeastern portion of St. Croix. The southshore area was once rich in Elkhorn Coral *(Acropora palmata),* and a variety of other hard corals. In the surf zone, Fire Coral *(Millepora squarrosa)* was at one time abundant (USACOE, 1976).

At an area offshore of the airport, *Acropora palmata* predominates with nearly 50% live coral cover along the fore reef. The fore reef in Manning Bay is dominated by *Diploria clivosa, Diploria strigosa,* and *Siderastrea radians,* with only 0-4% live coral cover. Canegarden Bay fore reef is dominated by *Porites astreoides,* with 4.4% live coral cover (Tetra Tech, 1991d).

2.4.3 Endangered Species

The U.S. Endangered Species Act defines "endangered species" to mean a species or subspecies that is in imminent danger of extinction throughout all or a significant portion of its range. "Threatened species" are those likely to become endangered in the foreseeable future unless current trends are reversed. Such species are protected by Federal law; neither the whole animal or any products from it may be taken, sold, or possessed. Alteration of the habitat in which any of these species occurs may be prohibited or constrained.

The V.I. Legislature has also passed endangered species legislation. Known as the Indigenous and Endangered Species Act of 1990, the bill (Act 5665), signed into law in December 1990, authorizes the Commissioner of DPNR to promulgate a list of endangered and threatened species in the Virgin Islands. The V.I. Government, Department of Planning and Natural Resources, Division of Fish and Wildlife maintains a list of locally endangered or threatened species.

At least two federally listed endangered bird species, and at least 13 locally listed endangered bird species, have been reported within the APC boundary. The federally listed species are the Brown Pelican *(Pelecanus occidentalis),* and the Peregrine Falcon *(Falco peregrinus).* The Brown Pelican is

known to roost at Billy French Ponds and to feed at various locations along the shore. The Peregrine Falcon is extremely uncommon on St. Croix, but has been reported at Billy French Ponds.

The locally listed endangered bird species reported within the APC include the following: (Knowles, pers.comm., 1992):

1. White-tailed Tropicbird *(Phaethon lepturus);* reported to nest east of Billy French Ponds (BFP)
2. Great Blue Heron *(Ardea herodias);* recorded at BFP and Manning Bay Great (Common) Egret *(Casmerodius albus)*
4. Snowy Egret *(Egretta thula)*
5. Black-crowned Night Heron *(Nycticorax);* reported at BFP and at Manning Bay.
6. Bahama Duck *(Anas bahamensis);* reported at BFP and at Manning Bay; possibly nesting at Ruth Cay.
7. Clapper Rail *(Rallus longirostris);* likely to occur at Manning Bay, although unconfirmed.
8. Caribbean Coot *(Fulica caribea);* not common on St. Croix; reported at BFP.
9. Snowy Plover *(Charadrius alexandrinus);* reported at Texaco tank farm beach following Hurricane Hugo; likely an accidental sighting.
10. Willet *(Catoptrophorus semipalmatus);* probably on Ruth Cay, although unconfirmed; seen on wetland area at site of proposed WAPA power plant.
11. Least Tern *(Sterna albifrons);* reported at Ruth Cay, at Manning Bay, and at Hess property.
12. Royal Tern *(Sterna maxima);* reported at BFP and feeding offshore
13. White-crowned Pigeon *(Columba leucocephala);* approximately 500 breeding pairs on Ruth Cay.

The Fisherman Bat *(Noctilio leporinus)* is known to occur along the southshore coast and is likely to utilize Billy French Ponds.

Loggerhead *(Caretta)* and Hawksbill *(Eretmochelys imbricata)* sea turtles have been reported for Limetree Bay (Prince-Tams Joint Venture, 1984), although it should be noted that Loggerhead turtle sightings have not been confirmed for the U.S. Virgin Islands by DPNR/DFW and are believed not to occur in these waters (pers. comm., R. Boulon, DPNR/DFW). Rees & Associates (1991) repōrt an unconfirmed sighting of a Leatherback sea turtle *(Dermochelys coriacea)* offshore of the proposed new power plant.

The St. Croix Ground Lizard *(Ameiva polyps)* has been introduced to Ruth Cay (section 2.4.1).

2.5 Cultural Resources

2.5.1 Prehistoric

There is one registered prehistoric site near the APC boundary; it is located in Estate Enfield Green. It is classified as a high priority site eligible for listing in the National Register of Historic Places (NRHP), but not yet nominated (OAS, n.d.). This site is the only known Preceramic site on St. Croix. It dates to 2,000 to 3,000 B.C. (pers. comm., B. Tilden, Ft. Frederiksted Museum).

Prehistoric material has been located in an area north of VIALCO, near the highway, but the site was probably destroyed during the plant and/or road construction (pers. comm., B. Tilden, Ft. Frederiksted Museum).

On the western end of the APC, the potential for prehistoric resources is extremely high all along the southern shore. Site 12VAml-38 is a potential, unverified site, at Envy south of the Alexander Hamilton Airport runway, and it is highly likely that other sites are present between Envy and Enfield Green. Shell deposits found by Alfredo Figueredo at Betty's Hope and identified as preceramic cultural remains are of dubious validity as a prehistoric cultural site. It was reported to the DAHP that these deposits were removed by erosion associated with Hurricane Hugo (pers. comm. E. Righter, DPNR/DEP).

A known Saladoid site, 12VAml-32 is present on the shore at Enfield Green; and, given the presence of a large fresh water gut in the area, it is likely that the prehistoric site extends northward onto the flat plain of Enfield Green. Both Enfield Green and Betty's Hope have been disturbed by historic land uses, which have perhaps affected prehistoric deposits; but the historic ruins on both properties are, themselves, significant historic resources.

The Fairplain prehistoric site, 12VAml-10, which was situated along Bethlehem Gut east of the airport, was virtually destroyed by construction of the airport access road. It is possible, however, that traces of this site, or loci associated with it, are still extant on the slope east of the access road and elsewhere in the vicinity. The ruins of Estate Anguilla are visible east of the airport, within the APC; while the remains of Spanish Town and Annaberg also are in the area northeast of the airport and may contain buried historic archaeological resources (pers. comm. E. Righter, DPNR/DEP).

On the eastern end of the APC, a prehistoric site, 12VAml-45, is located on the shore of Cane Garden Bay and the restored Canegarden Bay Estate House and ruins of outlying buildings lie adjacent to the eastern edge of the APC. This property is being nominated to the National Register of Historic Places.

Limetree historically was a port for small vessels and it is possible that shipwrecks are present offshore.

2.5.2 Historic

A Colonial cemetery is located in an area within the VIALCO property. Most or all of the tombstones were knocked over by a bulldozer (pers. comm., B. Tilden, Ft. Frederiksted Museum). Also within the VIALCO property are the remains of three plantation era homesteads. One of these is visible from the main highway.

2.6 Built Environment

Figure 9 depicts a generalized schematic of existing land use categories. Figures 10a and 10b depict the major land use activities which presently occur within the Southshore Industrial Area.

2.6.1 Roads and Ports

Four major roads comprise the boundary of the APC, including Route 64 (the Airport Road); Route 66 (the Melvin Evans Highway); Route 68 (the northern boundary of HOVIC property); and Route 62 (which forms the easternmost boundary of the APC). While these roads all receive moderate to heavy vehicular traffic, especially during shift turnovers at HOVIC and VIALCO, they do not experience major tie-ups.

Until completion of the new Containerport in 1983, most marine transported cargo was handled at Gallows Bay docks in Christiansted. With the development of the new Containerport, however, and its 35-foot deep channels and berthing facilities, virtually all marine cargo operations have been shifted to the southshore. The Containerport consists of a 1020-foot long by 200-foot wide pier.

Other major port facilities in the southshore area include the HOVIC tanker terminal located eastward of Limetree Bay, and Port Alucroix, site of the VIALCO plant (Figures 10a and 10b). The HOVIC facility has a 500-foot wide channel and can accommodate vessels up to 60-foot draft. The Alucroix Channel is maintained by VIALCO, and includes a 300-foot long, 35-foot deep channel which leads to Port Alucroix. A subsidiary channel provides access to the Containerport via a 38-foot deep cross-channel, and another secondary channel provides intake water for VIALCO operations.

The Alexander Hamilton Airport is located immediately outside the APC boundary, inland from the Manning Bay shoreline. The airport is an international port of entry and is capable of handling most long haul aircraft needs. In looking ahead at future needs (Year 2000 or so), the Virgin Islands Port Authority has identified the possibility of a major parallel air carrier runway that would be located south of Airport Road (Bristol, Childs & Associates, 1979). However, Port Authority currently has no plans to pursue an additional runway (pers. comm., D. Brin, Port Authority).

2.6.2 Water Systems

St. Croix's dependence on desalinated seawater has increased since the first plant was installed in 1966. Several different types of distillation units have been installed and tested at the WAPA desalination plant at Richmond, west of Christiansted.

The VIALCO plant has two 1 MGD desalination units. WAPA is negotiating with VIALCO to purchase desalinated water to augment public supplies. Barged water from Puerto Rico is used occasionally, but is not a significant water source for St. Croix. A description of the island's water distribution system and proposed improvements toward the year 2000 is found in CH_2M Hill Southeast (1983).

The groundwater resource potential of St. Croix is good due to the island's favorable topography and geologic formations which enhance infiltration and recharge rates. All three types of aquifers that are commonly found in the U.S. Virgin Islands exist on St. Croix: fractured rock, solution cavities (marl), and sand/gravel beds. Public supply wells generally utilize the latter two types (CH_2M Hill Southeast, 1983). Groundwater is inexpensive, but of poor quality due to relatively high mineralization and, occasionally, contamination from pump oil lubrication (CH_2M Hill Southeast, 1983). The latter problem is no longer as significant as it once was, as most of the oil-lubricated shaft turbine pumps

have been replaced with electrical submersible pumps. The few remaining are expected to be replaced soon (pers. comm., A. Schottroff, DPNR/DEP).

The principal aquifer on St. Croix is the Kingshill Aquifer, which yields approximately 1.0 MGD (USVI Govt/DPNR, 1992b). WAPA operates six major well fields on St. Croix, comprised of nearly 50 wells (not all in active production). Several hundred private wells are in operation. Commercial well-field operators pump and truck groundwater for sale.

2.6.3 Wastewater Systems

St. Croix's sewage pumping and treatment facilities consist of a primary sewage treatment plant (STP), built in 1972 at Estate Anguilla (Figure 10a), and 14 pump stations. The STP was designed to handle flows of 4.0 MGD and, as of May 1992, flows average approximately 2.8 MGD (Tetra Tech, 1992). The STP operates at 50% capacity on dry days, and at near full capacity during rainy periods, an indication of the amount of stormwater infiltration/inflow in sewer lines (Strategic Planning Group, 1991).

Under the Territorial Pollutant Discharge Elimination System (TPDES), the St. Croix STP is classified as a "major" facility because it receives more than 1.0 MGD of wastewater. The STP has a 1.9 mile ocean outfall located immediately south of Estate Anguilla (TPDES permit No. VI0020036). An independent rum distillery (Brugal Rum Factory) is permitted to discharge 3000 GPD into the STP outfall (pers. comm., M. Pacifico, DPNR/DEP).

The STP and four of the major pump stations require rehabilitative improvements (USEPA, 1992). Only one of three pumps at the Fig Tree pump station, for example, were operable during an October 1992 site visit; another of the pumps was burned out; the third has never operated since commissioning of the station in 1977. The use of salt water flushing systems, and the high wastewater strength (a result of limited water availability), have contributed to the advanced deterioration of the entire system. The result has been numerous breakdowns during the past several years, requiring raw sewage to be pumped directly into nearshore receiving waters while maintenance on the system is carried out.

2.6.4 Energy Systems

Power for St. Croix is currently generated at the Richmond power plant on the outskirts of Christiansted. Power outages are numerous, as demand has surpassed supply. A new 22 MW power plant is scheduled to be constructed by WAPA during 1993 within the APC at a site east of VIALCO and west of the Containerport. The two large industries, HOVIC and VIALCO, operate independent power systems for their operations.

2.6.5 Solid Waste Disposal Systems

St. Croix's only municipal solid waste landfill (the Anguilla landfill) is located west of the VIALCO property and east of the Airport within the APC. Although situated inland from the now closed coastal landfill, the new site is again encroaching on the shoreline and is considered beyond capacity. Water quality standards (secchi disk and turbidity) are frequently exceeded, a result of combined

shoreline erosion from wave action and surface runoff from the landfill (pers. comm., M. Pacifico, DPNR/DEP).

The location of the Anguilla landfill has created a growing concern for the Federal Aviation Administration (FAA) with an increased frequency of "bird strikes" at the Airport. Flocks of cattle egrets are known to frequent the Anguilla landfill, and several planes have been struck in recent years. According to FAA regulations, the landfill is considerably closer to a take-off/landing zone than the acceptable minimum distance permitted for such a facility. The Port Authority is currently operating the Airport under a FAA waiver with respect to the landfill, but it is not known how much longer the FAA will continue the waiver.

3. RESOURCE USE, USE CONFLICTS, AND ADVERSE IMPACTS

3.1 Resource Use

Figures 10a and 10b depict the principal land uses within the APC.

The principal facilities located within the APC, in addition to the various port facilities, include the HOVIC oil refinery, the VIALCO alumina plant, the container port operated by the Port Authority, and the sewage treatment plant and solid waste landfill, both operated by the Department of Public Works. A 22 megawatt power plant, to be operated by Water and Power Authority, is planned for construction in 1993 (pers. comm., D. Brin, Port Authority).

The HOVIC facility is situated on approximately 2000 acres of land and includes a new $1 billion fluid catalytic converter (FCC), presently under construction, other petroleum refinery facilities, oil storage tanks, settling ponds, docking facilities, staff quarters, and other support facilities. HOVIC currently has approximately 900 full-time employees, plus an additional 4000 temporary employees working on the new FCC plant.

There are actually three separate refineries in operation: the west refinery, the east refinery, and the SCPC plant (St. Croix Petrochemical plant) on the southern property. HOVIC has a TPDES permit to discharge industrial wastes and stormwater through an ocean outfall.

The facility relies on offshore fuel transport pipelines to assist in off-loading crude oil. Over 1000 "very large crude carriers" (VLCCs) call at these facilities each year, but, due to harbor limitations, the larger vessels must be first lightered at a Hess facility in St. Lucia before calling at the HOVIC terminal. The HOVIC terminal is serviced by VLCCs ranging from 130,000 Dead Weight Tonnage (DWT) to 185,000 DWT (HOVIC, 1993).

HOVIC has recently (mid-1992) cleared a 300 acre tract east of their present compound (and north of Billy French Ponds), and has plans to construct new staff housing at that location.

The new FCC is a state-of-the-art facility which will be used to further refine long-chain hydrocarbons into lighter fuels. Construction of the facility is partially in response to Clean Air Act regulations which will require the general use of more refined (cleaner burning) fuels in the future. The

plant will have its own dust monitoring systems and a state-of-the-art waste treatment system (pers. comm., P. Avery, HOVIC).

Two "land farms" on HOVIC property are used to dispose of oily sludge and other wastes that are not federally listed and regulated by the USEPA. HOVIC is evaluating the feasibility of installing anaerobic digestion tanks for these wastes. The HOVIC main outfall carries stormwater and treated process water and discharges through a shoreline culvert on the east side of the west HOVIC port. Nine water wells are in operation along the HOVIC north property line; they pump approximately 150,000 GPD of groundwater, at least some of which is used as process water in the refineries. The location of groundwater discharge wells and the high rate of pumping along the HOVIC property is designed to contain and recover oil that has leaked into the ground underneath the refineries from contaminating groundwater supplies outside HOVIC property (section 3.3.1) [HOVIC, 1992].

The VIALCO alumina plant occupies approximately 1400 acres at the head of Alucroix Channel. VIALCO is the successor to Martin Marietta, which purchased the plant from the Harvey Alumina Corporation in the late 1960's. Martin Marietta closed the plant in 1985 and sold the plant in 1989 to VIALCO at a price of $45 million. The plant is reportedly operating at full capacity today, producing nearly 700,000 tons of alumina per year. There are 435 full-time employees.

Alumina is an intermediate product used in making aluminum. Approximately 1 million metric tons of bauxite ore are shipped each year from South America to VIALCO, where the ore is dissolved with concentrated caustic soda to extract alumina. Approximately 250,000 metric tons of red mud residue is formed as a by-product, and has to be washed free of the caustic soda. Massive tailings piles (450 acres and 50 feet high) and settling ponds are used to dispose of these and other by-products of the process. Other ancillary processes involved in alumina production at the site are bauxite crushing and grinding, red mud sedimentation and washing, clear liquor filtration, vacuum flash heat interchange, seeded crystallization, calcination, electrical power, and steam and air generation and distribution (VIALCO, 1991). VIALCO has a TPDES permit (No. VI0000027) to discharge desalination brine (21 MGD), sand transport (0.25 MGD), stormwater (0.73 MGD), and non-contact cooling water (24.75 MGD).

The alumina plant, settling and cooling ponds, tailings piles, staff housing, and other support facilities occupy most of the site. A large recreational area is maintained for public use, which includes a community hall that is available by reservation. Three historic ruins (from the sugar plantation era) remain on VIALCO property today.

A UVI-sponsored aquaculture research project is proposed for a section of the VIALCO water intake channel. Permits are being sought (as of late 1992) to allow aquaculture research on a hybrid variety of Tilapia to be grown in cages attached to rafts. The project is designed to determine the technical and economic feasibility of such an enterprise, and the fish will be sold to a local market during the three year pilot study.

In 1984, the Port Authority released masterplans for its Third Port Project. The project, designed in three phases, calls for the development of a deepwater port in Limetree Bay (between the Container-port and Alucroix Channel), for the handling of molasses, other bulk cargoes, containers, construction

materials, and equipment. The initial phase of the project was implemented with the construction of the existing Containerport at the eastern side of the Bay.

Most of St. Croix's cargo is handled at the Containerport. It is comprised of a 1020-foot long pier with 35 feet water depth along its west side, and a roll-on/roll-off ramp at its inshore end.

The Port Authority's masterplan calls for the development in stages of a general cargo wharf paralleling the entire 2300-foot shoreline, extending from the Containerport ramp to the Jetty at Alucroix Channel. An additional pier would be constructed alongside the Alucroix Channel for the handling of liquid bulk cargoes (especially molasses destined for the rum distilleries). In phase I, the entire harbor would be dredged to 35-feet below mean low water (MLW); a 1070-foot long pier constructed; and a 65-acre upland area filled with dredged material to create cargo storage facilities. In phase II, another 1070-foot long pier would be constructed, the cargo storage area paved, and crane rails and cranes installed at the general cargo wharf. In phase III, additional storage shed facilities would be constructed, along with possible additional dredging to deepen the harbor and channel to 39-feet below MLW. However, Port Authority currently has plans to proceed only with construction of the liquid bulk cargo dock (pers. comm., D. Brin, Port Authority).

As compensatory mitigation for the loss of seagrass beds in the proposed dredge area, a seagrass transplantation project was designed and implemented in 1987. Three species of seagrass (section 2.4.2) were transplanted to selected sites near Ruth Cay, where they were subsequently monitored for attachment and growth. In summary, significant portions of the transplants survived the effects of Hurricane Hugo and were found to be alive and healthy when last monitored in 1990 (Coulston, 1990).

Certain portions of the (Phase I) Third Port project were initiated in the early 1990's until the USACOE stopped the project for violations of the Section 404 permit. The Port Authority was allegedly using wetlands (as dredge spoil ponds) outside of those specified in the permit. The USACOE required that the Port Authority restore the area to its previous elevation.

Also under Port Authority control, the Alexander Hamilton Airport occupies land west of VIALCO to the Texaco tank farm (with the exception of the landfill and sewage treatment plant). A portion of the airport property is located within the APC. The Port Authority is currently (late 1992) in the process of revising the AHA masterplan, including projected uses for that portion of the land within the APC. The work is being done by Bristol, Childs & Associates, and is scheduled for completion in March of 1993. Upon completion of the Airport Masterplan update, the Port Authority will undertake a land use analysis of its land south of Airport Road, along Manning Bay.

The Department of Public Works operates the island's only municipal solid waste landfill on 20-30 acres west of the VIALCO property and east of the Airport. The Anguilla landfill is located inland from the now closed coastal landfill site. The DPW is working to quantify the island's waste stream and to promote methods to reduce the volume of waste that must be disposed at the landfill. The proximity of the airport is a problem, as the landfill periodically catches on fire, wherein the smoke reduces visibility and creates concerns for aviation safety. Furthermore, regulations under the Clean Water Act will require the present site to be closed by October 1, 1996. The DPW would like to

identify another site for the landfill, and at the same time move toward more integrated solid waste management programs, including waste reduction, reuse, and recycling.

The Department is assessing the feasibility of establishing a waste recovery and processing center in the area, which will include scrap metal processing and parts recovery from derelict automobiles. Approximately five acres are needed for the scrap metal site, but DPW is exploring the use of the entire 14 acres of previously closed landfill along the coast as a site for its longer term plans to establish an integrated solid-waste management facility. Such a facility would presumably focus on the recovery of light weight materials, and would involve operational separation, packaging, and shipping. Proper design of the area is necessary, including fire breaks, fire lanes, berms, and buffer zones.

A stormwater discharge permit is required to operate the landfill under the Clean Water Act, which established an October 1, 1992 application deadline for the required TPDES permit. As of this date (December 1992), no TPDES application by DPW has been submitted to DPNR/DEP. As seen above (section 2.6.5), water quality monitoring of the area has revealed recurrent violations with respect to turbidity. The DEP is currently not monitoring landfill operations, nor has it pressed for compliance of the TPDES permit requirement.

A Government-owned abattoir is situated nearby, along with an auto drag racing strip and grandstands for viewers. Other proposed uses for the nearby coastal area include the construction of a small boat marina and a boatyard.

DPW operates a large (4.0 MGD capacity) sewage treatment plant (STP) near the landfill. A 1.9 mile ocean outfall discharges effluent from the STP, which processes sewage pumped from Frederiksted, Christiansted, and outlying areas along the collection route. DPW is currently assessing the feasibility of extending the ocean outfall, well beyond the coral reefs, as support for the Territory's 301(h) application to USEPA for a waiver on secondary treatment requirements.

The Flamboyant Racetrack is located west of the landfill and STP, just south of the Airport. The horse racetrack is located on Government-owned land, and is adjacent to a healthy mangrove shoreline.

The Water and Power Authority plans to increase its generating capacity for power on St. Croix by installing a 22 megawatt gas-powered turbine generator at an 8.5 acre site located between the Containerport and Alucroix Channel. The construction of the new power plant is intended to increase the reliability and efficiency of the St. Croix power system, and provide a back-up source of power when the Richmond plant (near Christiansted) is down. No marine structures are required and no TPDES permits are necessary on this phase of the project.

The U.S. Army Corps of Engineers has given tentative approval for construction of the power plant. Compensatory mitigation for lost wetlands will be required; approximately four acres of wetlands will be restored at an area south of the horse racetrack in Manning Bay. It appears that construction of the plant will begin in late 1993 at the earliest.

Texaco occupies a land-based storage facility/tank farm located at Estate Betty's Hope at the western end of Manning Bay. The facility has a TPDES permit for a stormwater discharge outfall. Offshore unloading facilities are no longer in use.

The Virgin Islands Rum Industries, Ltd. (VIRIL) is located on the western boundary of the APC and utilizes a 1900-feet ocean outfall which terminates offshore at about 18-feet depth. Rum by-products, called mostos, have been discharged at the site for over 20 years through a ten inch pipeline that was originally a V.I. Government sewer line. VIRIL is permitted to discharge 115,000 GPD of untreated mostos at a maximum temperature of 48° degrees C, and at 65° degrees C for 96 hours/month. The pH of the discharge is usually acidic within a permitted range of 4.5-9.0 (conditions of TPDES Permit No. VI0000027 as stated by M. Pacifico, DPNR/DEP). Sanitary wastes from the distillery are discharged separately into the municipal sewer (Sigma Environmental Sciences, 1976).

A groundwater survey of central St. Croix was undertaken by the USGS in 1987. Significant changes were found in withdrawal rates from the Kingshill aquifer. For the period 1983-1987, groundwater withdrawals in the south-central part of the aquifer increased from less than 50,000 GPD to about 0.5 MGD. This greater usage rate, coupled with the mid-1960's dredging of Krause Lagoon which lowered water tables and recharge rates, likely explains the difference in potentiometric groundwater surface levels (essentially, a measurement of the height of the water table) recorded in 1987, which were as much as 5 feet lower than previously recorded (Torres-Gonzalez and Rodriguez del Rio, 1990). The same survey estimated a daily discharge rate of 150,000 GPD for multiple wells operating within the immediate Southshore Industrial Area (Figure 11).

3.2 Use Conflicts

Although the Southshore Industrial Area is zoned for heavy industrial use, zoning boundaries do not necessarily serve to contain the many impacts which emanate from industrial processes (Figures 12a and 12 b). Moreover, adjacent areas are growing in both residential and commercial use, placing increased demands on groundwater resources and contributing of themselves new sources of pollution that must be assimilated by the environment downslope (or down current). Thus, conflicts regarding air and water quality have become of greater issue in recent years, and should be expected to increase further in the absence of viable mitigation strategies.

Overall **air quality** within the APC is better than which is found in most major urban areas of industrialized countries. Air pollution is, nevertheless, of concern for local residents. For several years, at least some residents downwind of the industrial area have suffered the ill effects of reduced air quality. Such effects include itchy and burning eyes, irritated respiratory tracts, and upset stomachs. Complaints of odors similar to that of rotten eggs and/or onions have been reported, with such odors lingering for up to 30 minutes (James, pers. comm., 1992).

The alleged source of the noxious fumes is often the oil refinery, but investigations by local authorities reveal a number of different air contaminant sources. Suspended particles (dust), for example, originate from the solid waste landfill, from any one of at least five sources of dust stemming from VIALCO operations, from the daily removal of soot from boiler stacks at HOVIC, from asphalt plants and/or a concrete batch plant operating on land adjacent to the APC, or from construction sites, traffic, and several other potential sources. Sahara dust (dust which originates on the African continent and

carried here via the upper atmosphere) is an unquantified source of dust for the entire Territory. Moreover, several studies have emphasized the adverse effects of ship emissions on air quality. Large ships, such as those which frequent the HOVIC and VIALCO ports, frequently use steam turbine engines fueled by bunker oil (No. 6 oil) with high sulfur content (2-3%).

Air quality issues are complex and, for the Southshore Industrial Area, have never been fully investigated to ascertain the "broader picture" of air quality within the APC. Point source air emissions (those from a single industrial activity) are the traditional focus of environmental monitoring efforts, whereas the aggregate or cumulative impact from combined sources is as yet unstudied.

A similar situation exists for **groundwater quantity and quality**. Whereas groundwater supplies are needed to support the industrial activities in the area, excessive discharge (pumping) of groundwater may in fact have long-term impacts on the island-wide availability and quality of water. Modeling of the Kingshill aquifer by hydrologists of the U.S. Geological Survey has indicated that discharge rates in excess of 1.2 MGD may induce saline intrusion (Torres-Gonzalez, 1990). This may be partially offset with the construction of new recharge sources, such as surface retention basins. However, not enough is currently known about the total water budget of the Kingshill aquifer, and there is some indication that potentiometric groundwater surface levels may have declined during the last two decades (section 3.1).

Contamination of groundwater occurs from many sources, and the potential for major contamination from spills in the industrial area should not be discounted. Oil has leaked into the ground over the course of several decades at the HOVIC refinery, and a recovery program is currently underway. The exact dimensions of the problem are not clear; HOVIC reports that on the order of 10 million gallons of oil reside underneath the refinery (HOVIC, 1992). The Barren Spot well field north of HOVIC property has been recommended (in 1983) for routine monitoring for heavy metals and petroleum contaminants (Geraghty and Miller, 1983). Other well fields, including the Adventure well field within the APC watershed, have had problems or have been shut-down due to contamination, although no definitive connection has been established between the HOVIC groundwater contamination and that of other wells in the area.

The Adventure well field contamination may very well not be due to HOVIC contamination. Three or more sources are more likely possible sources of contamination. These include: a Texaco station just north of the wells; a car lot (formerly an auto junk yard) adjacent to the gas station; and the Department of Agriculture property where fuel was previously stored. Groundwater flow is north to south. HOVIC is south and east of the Adventure well field. Also, Barren Spot well field, which is between HOVIC and Adventure, is not contaminated by hydrocarbons, except for one well that was contaminated when a pump self-destructed (pers. comm., A. Schottroff, DPNR/DEP). It remains possible, however, that other wells in the vicinity of HOVIC may be contaminated by HOVIC oil.
Another resource conflict of increasing concern is that of the **tailings piles** (red mud) produced by the VIALCO alumina plant (section 3.1). These tailings have accumulated on the property since original operations were commenced by the Harvey Alumina Corporation in the late 1960's. They are considered "mine tailings" by the USEPA (and not a toxic discharge), and so are exempt from Resource Conservation and Recovery Act (RCRA) regulations. The visual impact from these piles is considerable; information on other impacts and on possible toxicity is not available. Space at the red mud tailings site is limited, and so an expansion area will be needed in the near future. Although

VIALCO is exploring options for improving stockpiling operations of the tailings (e.g., sloping of exterior walls, a runoff system at the base, resurfacing and vegetation), important questions remain unanswered, for example, how long will VIALCO be allowed to stockpile these wastes and what will become of them?

At the east end of the eastern Billy French pond, a residential access road has restricted the hydrology of a localized wetland, resulting in the decreased size of productive wetland and **reduced habitat** available for wading shorebirds.

As discussed above (section 2.6.3), **sewage bypass** discharge is an all too frequent occurrence on St. Croix and affects the APC primarily from discharges at the Fig Tree pump station. The DPW is required to notify DPNR/DEP and USEPA in the event of a bypass, but there is no requirement for public notification. Sewage bypass discharges and the use of polluted waters by the public can result in problems affecting public health, safety, and welfare, including the potential for infections of skin, eyes, and ears; intestinal disorders; and/or hepatitis or cholera. Moreover, public confidence in the responsible agencies and officials is undermined by the current lack of public notification. Potential loss of revenue from tourism and business is an indirect impact as yet unquantified.

At the east side of the mouth of Alucroix Channel, a derelict concrete tanker ship (known as the "WIT II Barge" and owned by the West Indies Transport Co.) is moored. The barge was originally brought from St. Thomas for the purpose of storing ethanol, but it was never used for this purpose. It is a significant visual and physical obstruction in the area.

Navigational conflict in Alucroix Channel is another problem of occasional frequency. This generally occurs when one of VIRIL's molasses ships is tied-up in the Channel to unload its cargo at the same time as one of VIALCO's large ships from Brazil needs to use the channel. VIALCO has priority use of the channel, and so at such times the molasses ship must abort unloading and move to allow the VIALCO ship to pass. The situation will be rectified when the Port Authority fulfills its plans to construct new molasses receiving facilities at a new dock seaward of the existing dock (section 3.1). These plans have been on-hold for several years, since the USACOE halted the project due to violations of the Section 404 permit. Permit violations have now been resolved, and the project awaits the availability of funds (pers. comm., D. Brin, Port Authority). Although this "inconvenience" must be endured on the average of (at the most) twice per year, its economic impact should not be discounted.

Recreational and commercial fishing within the APC has been considerably curtailed since Krause Lagoon was filled and the industrial area created in the 1960's. Nevertheless, both commercial and recreational fishermen utilize the boat ramp at Alucroix Channel. Commercial fishermen employ fish traps and dive for conch and lobster. Problems have occurred, however, as a result of tanker propellers cutting the trap lines. The tankers are supposed to stay in the 100 fathom channel, but often cut the corner into Alucroix Channel to save time (Farchette, pers. comm., 1992). This problem could, conceivably, be compounded if and when the Third Port project is built. At such time, there would likely be the need for official delineation of sea lanes to avoid further conflict with fishermen.

Another potential future problem for fishermen is that of continued access to the Alucroix Channel fishing ramp. The several different landowners (i.e., VIALCO, HOVIC, Port Authority, and WAPA)

need to resolve land ownership conflicts in the area, and reach consensus on a public easement or access road. Only at such time can federal funds (available through DPNR/DFW) be utilized for improvements to the fishing ramp at Alucroix Channel.

In 1984, the DPNR/DFW was successful in securing the assistance of Senator Edgar Iles and Congressional Representative Ron deLugo in establishing a "Safe Fishing Zone" extending from the southwest cape of Sandy Point to the Southshore Industrial Area. The term "Southwest Anchorage" was deleted from the charts and a specific section added to the NOAA United States Coast Pilot, warning mariners of the fishing activities conducted in the area and requesting vessels to remain seaward of the 100-fathom contour in their approach and departure to the industrial complex. These measures were prompted by numerous complaints and incidents reported by fishermen which documented commercial vessels interfering with fishing activities. The problem still exists today; several cases have been pursued through the courts for gear losses sustained by fishermen (pers. comm., W. Tobias, DPNR/DFW).

Recreational fishermen fish mostly for snapper, barracuda, and bonefish at the Alucroix Channel boat ramp. Some fishermen utilize the area east of the proposed WAPA plant to launch their small boats, and others have been reported using cast nets for mullet in Billy French Ponds. Fishermen occasionally utilize the eastern portion of VIALCO property (area "C") for crabbing, and at least one man is known to make charcoal out of mangroves from this area (Dempsey, pers. comm., 1992). The eastern portion of VIALCO property has acquired a broad assortment of **derelict vehicles**, other **scrap metals**, and **liquid and solid waste** (including batteries and used oil), and at one time was a storage site for PCB-filled transformers following Hurricane Hugo in 1989 (Dempsey, pers. comm., 1992). The transformers were subsequently removed, but soil contaminant testing has not been carried out.

DPNR/DFW has indicated a desire to make improvements to fishing access at the southshore area by constructing new ramps or improving existing ramps used by fishermen. Federal funds are available for this purpose, but only for improvements on publicly owned land (Tobias, pers. comm., 1992).

Bird hunting occurs at Ruth Cay, although officials are working to stop the activity.

3.3 Adverse Impacts

The two major industries, HOVIC and VIALCO, have in recent years become the focus of increased environmental monitoring efforts by local and federal agencies. With respect to toxic emissions, HOVIC releases 19 of the 300 toxic chemicals monitored by the USEPA. Since beginning its operations, HOVIC has dramatically reduced the amount of toxic chemical emissions from its refinery. In recent years, however, reported emissions from 11 of the 19 toxic chemicals used by HOVIC have slightly increased, although in some cases these are apparently the result of improved reporting procedures (Treadway, 1991). At least four of the 19 toxic chemicals released by HOVIC are known carcinogens: asbestos, benzene, carbon tetrachloride, and nickel compounds.

According to the USEPA's Toxic Release Inventory, the HOVIC plant discharged 2.12 million pounds of toxic chemicals in the air, water, and ground in 1987, the first year of the inventory. The 1990 inventory indicated that the plant discharged 1.5 million pounds; a 29% reduction since 1987

(Treadway, 1991). Meanwhile, HOVIC continues to search for improved technologies and non-toxic substitutes.

VIALCO is not listed as a USEPA Toxic Release Inventory Site. USEPA officials however visited the plant in early 1992 to collect soil and waste samples for investigation of hazardous materials. Results from that investigation have not yet been made public. Local monitoring officials issued at least two administrative notices of violation to VIALCO in 1991 for "improperly monitoring discharge" (Steif, 1992).

The production of toxic compounds as a by-product of industrial processes cannot be avoided. Safer technologies and proper disposal practices can, however, be employed to mitigate environmental and public health impacts.. Moreover, non-toxic substitutes are increasingly available for certain industrial processes.

3.3.1 Water Quality

Water quality offshore of the Southshore Industrial Area suffers from high turbidity levels and reduced oxygen levels. The territorial Government has designated these as "Class C" waters, with the identified goal of maintaining "the propagation of desirable species of marine life and primary contact recreation (i.e., swimming, water skiing, etc.)" (V.I. Code, Title 12, Chapter 7, Subchapter 186). For the purpose of determining whether the St. Croix STP outfall is adversely affecting the marine environment, a determination necessary for the 301(h) waiver (section 3.1), USEPA has made a determination that the waters surrounding the outfall are "stressed waters". This is based on the fact that the site is down current from several major discharge and former dredge sites.

Coastal waters are used for industrial cooling and waste discharge, and are additionally burdened by suspended sediments as a result of natural wind and wave effects which stir shallow bottom silts. This is exacerbated by propellor wash of bottom sediments, occasional dredging, and nonpoint source discharge from stormwater runoff. The St. Croix STP is continuously in violation of effluent limits for BOD (Pacifico, pers. comm., 1992). Coastal water quality is routinely monitored by DPNR/DEP St. Croix. A 27-foot diesel-powered boat is maintained by the department for this purpose.

A 1986 study looked at toxic substances in the coastal environment of the U.S. Virgin Islands. The study concluded that while the highest concentrations of inorganic trace elements were found in the fine sediments nearshore to HOVIC, impacts are localized, and in fact the USVI marine environment is in general relatively free of contaminants (Oostdam, 1986). However, back in 1978, the Puerto Rican-based Center for Energy and Environmental Research was involved in a rum-slop ecological study conducted for the Office of Research and Development of the U.S. Environmental Protection Agency. In this study, the VIRIL discharge site was visited in order to conduct a species census. The absence of seagrass within the plume site appeared to be associated with the rum-slop effluent. *In vitro* bioassays indicated that even the lowest concentrations of mostos tested (1:10,000) were lethal or altered the behavior of shallow water marine invertebrates (USFWS, 1991).

In April 1988, the USEPA conducted a toxicity test on the rum effluent using the marine invertebrate crustacean *Mysidopsis bahia*. They concluded that the VIRIL effluent is extremely toxic (with a 96-hour LC50 value of 0.74 percent by volume). An analysis (by heavy metal scan) of thirteen metals

showed elevated concentrations of arsenic, copper, and zinc. They noted that the concentrations of these metals singularly or together have the potential to cause serious and chronic water quality impacts on the receiving waters. Assessments completed by the USFWS indicate that the rum effluent, in addition to being toxic to marine organisms near the outfall, have the potential to affect nesting sea turtles down current at the Sandy Point APC (Oland, 1992). Although it is believed that the plume extends from the discharge point to Sandy Point with little mixing or dispersion, the hypothesis that the plume affects nesting sea turtles at Sandy Point has not been scientifically confirmed.

Runoff from the red mud tailings of the VIALCO alumina plant operation are another source of water pollution. While surface runoff into the cooling ponds is allowed, excessive nutrient loading (from the tailings) has resulted in algal blooms in the cooling ponds. [Note: VIALCO environmental staff believe the excessive nutrient loading to be the result of a leaking municipal sewer line along the north edge of their property. If true, this would warrant additional study to determine the exact nature and source of the nutrient loading.] Currently, suspended solids (comprised of filamentous blue-green algae and trace metals, including arsenic, chromium, copper, zinc, and lead) are being discharged into Alucroix Channel (USEPA, 1992b). Algal growth is spreading throughout the upper reaches of the channel (Pacifico, pers. comm., 1992). Algal blooms, if unchecked, deplete dissolved oxygen in marine waters with subsequent health and mortality effects on marine organisms.

Problems at the VIALCO cooling ponds have grown since 1985 when Martin Marietta shut-down the alumina plant and disposed of 14 million gallons of spent "liquor" (pH 13), a concentrated caustic soda. The USEPA approved the disposal method, which was simply to mix with sea water and to allow the magnesium hydroxide precipitate which formed to settle on the bottom of the cooling ponds. Today, this precipitate is several feet (estimates of 4-10 feet) thick, and is apparently a good substrate for the blue-green algae which is currently blooming out-of-control. VIALCO has plans to begin dredging the ponds in 1993. Spoils will be stockpiled at a site west of the existing red mud tailings. It is hoped that the cooling ponds will increase in efficiency with the dredging, as water temperature, sunlight reaching the lower depths, and alkalinity should all decrease with the deepening, resulting in less favorable conditions for algal growth (Black, pers. comm., 1992).

As indicated above (section 2.6.3), breakdowns of the St. Croix sewage treatment plant and pumping system result in the frequent bypass of raw sewage to coastal waters. Such bypass operations have their human impacts ranging from inconvenience and economic loss, to potentially serious health threats.

Within the APC, human contact with polluted waters is not common, although it does occur to a limited extent as swimmers occasionally use the Billy French Ponds and adjacent shoreline. Nevertheless, sewage bypass from both the STP and the Fig Tree pump station are of concern for the natural environment. In the latter case, raw sewage has been reported to flow directly into the eastern Billy French pond via Hess Gut, resulting in nuisance odors and the endangerment of fish and wildlife (USEPA, 1992). Similarly, fish kills have occurred at Manning Bay as a result of sewage bypass discharges into Bethlehem Gut from the STP on Estate Anguilla. The USVI Government is currently working to rehabilitate and/or replace equipment and structures of the STP and the four major pump stations on St. Croix, including alternative emergency power sources.

Groundwater contamination has occurred at varying levels within the APC and its watershed. According to the Division of Environmental Protection, the major sources of groundwater contamination Territory-wide, are (ranked by relative priority) as follows: septic tanks; municipal sewage infiltration; salt water intrusion; underground storage tanks; Hess oil refinery (USVI Govt/DPNR, 1992b). On St. Croix, sewage contamination has been of major concern in previous years (Geraghty and Miller, 1983). In addition, several well fields are in close proximity to the ocean and suffer seasonal fluctuations in groundwater salinity. Drought or excessive discharge can exacerbate high salinity levels, which can result in long-term damage to an aquifer.

In 1982, HOVIC discovered free-phase hydrocarbons in the ground at the western portion of the refinery. Numerous hydrogeologic investigations have since ensued, and a hydrocarbon recovery program initiated. To date, some 415,900 barrels have been reportedly recovered, and it is estimated that another 221,150 barrels (approximately 10 million gallons) of hydrocarbons remain in the ground below the refinery (HOVIC, 1992). Some 275 observation wells and approximately 90 recovery wells are in operation as of late 1992. HOVIC data indicate that no subsurface migration of hydrocarbon contamination has occurred beyond the refinery's boundaries (HOVIC, 1992). The entire procedure, including data from the well tests, hydrocarbon isopach maps, and groundwater elevation maps are reviewed monthly by HOVIC environmental personnel, and reported to the USEPA and the USVI Govt/DPNR as required under the operation's five-year Resource Recovery and Conservation Act (RCRA) permit. Meanwhile, HOVIC is rehabilitating and testing the refineries' tanks and piping systems on a regular inspection and maintenance schedule in order to reduce, if not eliminate, leakage and waste.

3.3.2 Air Quality

Legally, there are no "non-attainment areas" in the Territory at the present time with respect to compliance with National Ambient Air Quality Standards (NAAQS). Three areas, however -- Christiansted, Southshore Industrial Area, and Charlotte Amalie -- are potential non-attainment areas and deserve further ambient air studies from an area-wide, cumulative impact perspective (Shank, pers. comm., 1992).

Collection of ambient air quality baseline data is needed at all three sites. Clean Air Act regulations are coming on-line, although timeframes for various regulations have not been fully established. Air quality within the APC has on occasion presented problems to the surrounding populace (section 3.2). Suspended particulate matter (dust), oxides of sulfur and nitrogen, carbon monoxide, and hydrocarbons are the principal air pollutants. Sulfur dioxide (SO_2) levels are exacerbated by ship traffic in the area, and no emission controls are required for the marine industry. Suspended particulates arise from various sources (section 3.2).

The problem of air borne dust settling on roof-tops and washing into household cisterns is an as yet unstudied problem deserving of attention. A majority of people interviewed for this planning effort relayed concern for the potential adverse health effects which may stem from red mud dust from the VIALCO tailings piles entering household drinking water systems. While such concerns have as yet no scientific basis, they indicate a widespread belief that the issue requires investigation.

In the mid-1970's, a study found that the Southshore Industrial Area was, at that time, not in compliance with the NAAQS. The validity of the data was later questioned, but the study induced DPNR, in conjunction with the two industries, to initiate sulfur dioxide and dust (TSP) monitoring to obtain baseline data. Two SO_2 stations remain in operation (both are located on VIALCO property), and dust is monitored at three sites downwind of HOVIC and VIALCO.

Essentially all of HOVIC operations are regulated by the USEPA and the DPNR/DEP. Permits are required for major pieces of equipment, and general rules and permit conditions govern the types of fuels burned, stack emissions, unit throughputs, etc. (HOVIC, 1993). It is HOVIC's goal to always be below the 3 hr and 24 hr NAAQS for SO_2: 500 ppb and 140 ppb respectively (HOVIC, 1993). Stack emissions are typically products of combustion of petroleum fuels -- nitrogen oxides, sulfur oxides, carbon monoxide, carbon dioxide, and water.

Adding to poor air quality in the immediate vicinity of VIALCO are sewage gas (hydrogen sulfide and methane) emissions from the main public sewer line which runs parallel to the Melvin Evans Highway. A gas release port exists in that locale where a force main changes to a gravity main.

The Anguilla landfill catches on fire "frequently". The odor of burning trash is common at the Airport; one of the first experiences the visitor has upon arriving at St. Croix. The new Clean Air Act will require regulation of solid waste landfills, and so conceivably stricter controls will be placed on future operations at the landfill.

3.3.3 Noise Pollution

Industrial areas are not without noise impacts to surrounding communities. Environmental assessment reports for individual developments have examined noise impacts to the surrounding area (see for example, Rees and Associates, 1991, p. 65), but all have concluded that the incremental addition of noise from a proposed development will result in no significant impact due to existing noise levels emanating from the industrial area. It appears that no studies of noise impacts have been conducted with specific focus on target residential communities that may be affected by the cumulative impacts from various sources within the industrial area. The proximity of the airport to the APC currently exerts significant noise impact.

3.3.4 Impacts to Biological Resources

Ruth Cay is an important refuge for rare and endangered species (sections 2.4.1, 2.4.2), but is vulnerable to human and natural hazard threats. Uncontrolled human use, especially illegal hunting on the cay, is an occasional problem, as is shoreline erosion as a result of wave action on the man-made cay (Nellis, pers. comm., 1992). Increased human use of the cay could result in anchor damage to important seagrass beds, including the transplanted seagrass beds which, if protected, will provide important base line data in the years and decades ahead.

Benthic communities and other aquatic flora and fauna of the southshore area are vulnerable to turbidity and sedimentation effects (section 3.3.1). Dredging and filling have removed benthic habitat. The cumulative effects of habitat conversion and degraded water quality are not well understood for

marine environments, although lower overall biological productivity and increased mortality are expected results.

Wildlife species are also vulnerable to poor water quality on land, especially from sewage bypass discharges which occur at Billy French Ponds and at Bethlehem Gut on Estate Anguilla. Sewage bypass discharge entering the Billy French Ponds is the known culprit for at least two fish kills in the ponds to-date. Moreover, the construction of a residential access road at the eastern side of the eastern pond has eliminated a portion of the habitat that is normally available to wading shorebirds. The Billy French Ponds area is inhabited by feral dogs, a danger to both human visitors and, presumably, bird populations. Several bird species are known to nest amongst the cooling and settling ponds on HOVIC property.

The salt flats west of HOVIC and south of the HOVIC west refinery (actually, VIALCO's "Area C") are denuded of vegetation within an area outlined by a surface contour line, a situation which indicates water-borne contamination. Informed sources for this planning effort have identified several possible contaminant sources which may be contributing to the loss of vegetation in this significantly large wetland area. Among the possible explanations are:

1. hypersalinity resulting from periodic discharges by HOVIC of large volumes of seawater (used to conduct hydrostatic tests of refurbished oil tanks in the west refinery) via the nearby drainage gut;
2. surface runoff of herbicides used by HOVIC to control weeds within their compound;
3. surface runoff of oily residues escaping from a designated "fire training pit" on the west end of HOVIC near the salt flats;
4. subsurface seepage from a now closed area where leaded wastes were once "land farmed" (disposed in open pits);
5. altered hydrology as a result of upslope developments; and
6. an oil spill from HOVIC which discharged into the area in May of 1992.

It is likely that a combination of all or some of these factors is actually at work.

Least Terns *(Sterna albifrons)* are reported to nest in the area, and juvenile Laughing Gulls have used the area for staging prior to migration (Knowles, pers. comm., 1992).

The alteration of surface freshwater flows has exerted as yet unquantifiable impacts on the health and extent of wetland communities along the southshore. The airport area north of Manning Bay, and the eastern saltflats of the VIALCO property, are of special concern in this regard. Construction of the airport altered (reduced) surface flows from at least one important gut into Manning Bay. Freshwater flows are important nutrient sources and are essential for maintaining salinity balance.

In 1971, 3.5 million gallons of crude oil were spilled at the HOVIC port. The oil slick which floated west washed up on the west side of Alucroix Channel (south of the VIALCO cooling pond dike), and destroyed approximately 12.4 acres of mangroves. Shortly thereafter (in 1972), the USEPA prohibited Martin Marietta from continued direct discharges into the west drainage gut (adjacent to the present landfill site), and so the cooling pond dike was constructed to provide primary treatment (settling) of the plant process water. Several acres of mangroves died as their natural habitat was lost to the

cooling ponds, and Martin Marietta carried out a voluntary mangrove transplantation program in 1978 and 1979 along the Alucroix Channel, along the south side of the cooling pond dike and on the west side of Ruth Cay (Lewis and Haines, 1980) [Figures 13 and 14].

Prior to 1982, the VIALCO cooling ponds were drained by a series of 21 culverts along the pond's south and east sides. The cooling pond dike was washed out regularly, and oil is buried in mud on the south side of the dike (mostly from the 1971 oil spill). The culverts were closed in the early 1980's for reasons not fully known, and the present single floodgate was constructed. Approximately 45 MGD of water is discharged daily into Alucroix Channel through the floodgate. The health of the mangroves south of the cooling pond began to decline, possibly due to this change in hydrology, but also due to the heavy siltation they suffered in prior years from periodic overtopping of the dike by the cooling pond waters.

3.3.5 Impacts to Cultural Resources

The cultural resources of the Southshore APC are extremely vulnerable to developmental pressures. Adverse impacts to cultural resources occurred during the filling of the former Krause Lagoon to create lands for the industrial area. Several historic sites were further degraded during construction of the alumina plant in the early 1970's. Constant expansion of airport facilities threatens to intrude upon the archaeologically sensitive areas south of the airport; and, until the advent of Hurricane Hugo in 1989, land development pressures were so intense that almost all large tracts of land on the south shore were for sale or scheduled for development. While this pressure has temporarily abated, in the future, improved economic times will probably result in increased demand for development. Currently, the demand for affordable and low to moderate income housing has resulted in the development of large tracts of land. Recently, parcels set aside for other purposes have been sold for low to moderate income housing and it is not possible to predict where these residential areas will be developed (pers. comm. E. Righter, DPNR/DAHP).

4. MANAGEMENT RECOMMENDATIONS

4.1 Policy Framework

Better ways to address the emerging and worsening effects of the cumulative effects of pollutants within the APC are needed. Cumulative impacts are defined in the Council of Environmental Quality regulations (which implement the National Environmental Protection Act of 1969) as:

> the impacts on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal on non-federal) or person undertakes such other actions.

As with any coastal area, the public's right to physical and visual access to the coastline and the sea must be maintained (Beller, *et al.*, 1970). This will likely be an increasingly difficult policy objective to achieve within an area zoned for heavy industrial use. Advanced planning, however, can ensure that the most attractive public access points are designed into a masterplan for the entire area. The fishermen's ramp at Alucroix Channel is one such area that should be considered for further improvements and public access guarantees.

Other important land use policy issues include the need to locate public infrastructure and services in proximity to existing services and transportation networks and to encourage the private sector to "in-fill" along these established development corridors with multiple, mixed uses appropriately encouraged.

As the potential for groundwater use is relatively high on St. Croix, aquifer recharge areas should be given special protection and consideration for open space designation. Stormwater runoff velocities should be slowed through the combined use of vegetation and designed structures. Additional means to increase infiltration rates with, for example, a system of strategically located settling/recharge ponds should also be explored.

[Note: USGS is under contract with WAPA to conduct a pilot groundwater recharge project on St. Croix. At least two series of three dams -- one in the Golden Grove area and one in the Fair Plains area in River Gut -- have been constructed along with a monitoring well series to provide data on recharge rates. The monitoring series has water level transducers which continually record groundwater levels. The monitoring portion of the project has been postponed, however, due to lack of funds for staff and equipment maintenance (pers. comm., A. Schottroff, DPNR/DEP).]

Land use regulation should stress the importance of minimizing earth change work and the removal of vegetation, and the use of Best Management Practices on all new construction to minimize nonpoint source pollution effects.

The preservation of remaining habitat is especially important for the Southshore Industrial Area. Very little natural habitat remains within the APC, although biological recovery has progressed to the point where valuable habitat still exists.

Remaining wetlands and other diverse upland vegetation communities, rocky shorelines, cliffs, and beach/intertidal zones should be given express priority for conservation. These areas provide for a diversity of habitats needed to support the diversity of aquatic and wildlife species found within the area.

Efforts should be pursued to *promote the development of alternative energy sources, with the development of incentives for homeowners and business owners to use energy saving technologies,* including passive designs for the efficient use of wind and solar energy. Coupled with such efforts, *a waste reduction policy for St. Croix should be developed,* giving special attention to the industrial and other solid wastes generated within the APC. The safe and cost-efficient disposal of wastes will become a much larger issue for the Territory in the coming years, and is thus one issue deserving of extra planning effort at this time.

An official toxics reduction policy should be established, and government should begin to work with industry to identify programs, technologies, strategies, and material substitutes to encourage maximum feasible reduction of toxic and hazardous waste emissions or by-products.

4.2 Planning and Permitting

The majority of the Southshore Industrial Area is currently zoned as either I-1 (Industry Heavy) or I-2 (Industry Light) [Figure 17]. The large parcel of land south of the Airport is zoned P (Public Use). Areas outside of the APC boundary are generally zoned either A-1 (Agricultural) or R-2 (Residential Low Density). Permitted uses for these zones can be found in the V.I. Code, Title 29, Chapter 3, Section 228.

Since the late 1980s, DPNR/Comprehensive Planning staff have worked to prepare a Comprehensive Land and Water Use Plan that will re-designate all land and water in the Territory as one of ten (10) new designations, known as "Intensity Districts". The goal of the Comprehensive Plans is to ensure that the quality of life for island residents is maximized.

Natural Hazards Mitigation

There is a need in the Territory for an effective coastal storm hazard mitigation policy and plan. The siting of facilities along the coast increases a cumulative threat potential with respect to three types of coastal storm impacts: (1) threats to public health, safety, and welfare; (2) costs to tax payers for disaster relief and protection; and (3) losses of irreplaceable natural resources (Godschalk, *et al.*, 1989). Compounding the potential for catastrophic losses due to coastal storms is the possibility of significant sea level rise (SLR) in the decades ahead.

While average SLR over the last century has been less than one-foot (10-15 cm), an increase in that much or more (10-20 cm) is projected by 2025, and of between 1.5 and 6.5 feet (50-200 cm) by the year 2100. Using an average of 1 meter of shoreline erosion per centimeter of SLR (an average rate which may or may not represent the southshore area's actual erosion vulnerability), the resulting average by 2025 would be 33 to 66 feet (10-20 meters) [Godschalk, *et al.*, 1989].

A coastal storm hazard mitigation policy and implementation regulations should be developed for the Territory, and for the Southshore Industrial Area on a site-specific basis. A "development management" alternative to hazard mitigation is recommended.

As seen above (section 2.3.2), earthquake potential in the Territory is relatively high. Although slopes within the APC are generally negligible, the majority of development sits on landfill. *Appropriate attention should be paid in the design of major facilities, especially those which will house large assemblies of people, so that threats from seismic activity are absolutely minimized. Although liquefaction of landfill soils during a seismic event is not known for the Territory, logic suggests that certain compaction standards be adhered to, and a certified engineer's report required for all major facilities. Within the APC watershed, seismic hazards need to be incorporated into subdivision regulations, with strict controls on development in high hazard areas.*

Flooding mitigation will be an ongoing concern for new developments in many locations in the APC. As mentioned above (section 2.3.3), coastal and riverine floodplains exist throughout the area, and both the Canegarden Bay and the Alucroix Channel areas are designated sites in the Coastal Barrier Resources System.

Adherence to NFIP policies and regulations is highly recommended, and new developments restricted where the hydrology and flooding potential of an area may adversely affect important wildlife habitat. Channelization for flood control should be avoided, especially where sensitive mangrove communities will be impacted by the altered balance of fresh and saline water.

Water

One of the most significant coastal water quality concerns in the APC is that of chronic turbidity due to propellor wash of bottom sediments and other factors, some natural, some man-made. Unfortunately, mitigation strategies are limited. Given that much of the marine benthic environment is already degraded and that the area is highly dependent on its marine transportation network, perhaps this is a classical "trade-off". Where warranted, however, small-scale, site-specific mitigation of sedimentation effects can be accomplished through the use of siltation-curtains, wires, and cascaded settling ponds. Such devices should be routinely used on dredge and fill operations. Dredging can result in resuspension of fine sediments, and contaminant-laden sediments, with significant adverse impacts on coral reefs, seagrass beds, and other benthic communities.

Coastal water quality is adversely affected by oil spills and, as seen above (section 1.2), the potential for a major oil spill is high for the Southshore Industrial Area. Oil spill contingency plans are under preparation by both the USVI Government (DPNR) and the U.S. Coast Guard. The latter plan, which will be developed in coordination with the relevant federal and local agencies, is a revision of an earlier plan (Oil and Hazardous Materials Response Plan for Puerto Rico and the U.S. Virgin Islands), and has a July 1993 scheduled completion date as stipulated under the Oil Pollution Act (OPA) of 1990 and its regulations.

Under the new OPA regulations, vessels and facilities that handle any kind of oil are required to demonstrate that response capability exists. Personnel training, equipment, and exercise drills are required components. As such, the private sector is in large part joining forces to support the development of "cooperatives" that will provide the required "on-call" oil spill response capability. One of these cooperatives, the Marine Spill Response Corporation (MSRC) will have facilities, including a 210' vessel, on HOVIC property. Government facilities (e.g., the new WAPA power plant) must also meet the requirement to develop a site-specific oil and hazardous material spill response plan.

A 1971 oil spill (3.5 million gallons) at Krause Lagoon resulted in 12.4 acres of mangroves killed with little recovery after seven years (Lewis, 1983 as reported in Tetra Tech, 1991c). Two international oil spills (St. Kitts and St. Eustatius) have occurred during the last two years which have impacted waters of the U.S. Virgin Islands (Perry, pers. comm., 1992).

Oil impacts are not always from accidental spills. When the HOVIC west refinery oil tanks were built in the late 1960's, they were built without cathodic protection. As a result, HOVIC has to periodically shut-down operations to drain the tanks, repair them, and conduct hydrostatic tests (fill them with sea water) before recommissioning them. The sea water, plus any tank washings, is discharged directly into the nearby gut which empties into "area C" of VIALCO property. Several hundred tanks were rehabilitated in this manner as recently as post-Hurricane Hugo. There is no reason why this practice should continue.

HOVIC should be required to extend the main outfall west of its present terminus, and to direct all surface runoff from the west refinery into the outfall for treatment prior to discharge.

Another coastal water quality issue that should be promptly rectified is that of the algal bloom within the VIALCO cooling ponds. An independent investigation is warranted to determine if nutrients alone are the cause of the problem, and if the planned dredging of the cooling ponds will in fact ameliorate the situation. DPNR should work with VIALCO and come to quick agreement on a remediation schedule.

Runoff from the red mud tailings should be redirected into a separate series of settling basins, with treatment for removal of trace heavy metals prior to discharge. VIALCO should assess the feasibility of recirculating process sea water back through the plant, toward the goal of significantly reducing the amount of sea water used and discharged on a daily basis.

Another significant concern for both this APC and the Sandy Point APC, is that of the Virgin Islands Rum Industries Limited (VIRIL) rum outfall effluent. Carefully monitored bioassays by the USEPA in 1988 clearly demonstrated that the effluent exerts lethal and sub-lethal effects on marine organisms, and a recent video indicates a dense layer of dark liquid covering the sea floor at and down current of the outfall (Oland, 1992).

Additional independent tests of the effluent's toxicity should be undertaken (at VIRIL's expense), the outfall should be lengthened, and an appropriate diffuser mechanism be designed and installed to bring the outfall into compliance with the Territory's Water Quality Standards and mixing zone standards set forth in the state narrative for mixing zones. Toxicity levels, biological oxygen demand (BOD), and temperature are all suspect, and should be subject to immediate, additional testing. The requirement for effluent treatment should not be ruled out, as such is standard practice in the industry.

With respect to groundwater use, it is seen that the Kingshill Aquifer offers considerable potential to augment public potable water supplies for several years or decades ahead. It is of critical importance that plans and permit decisions recognize the importance of this irreplaceable resource, to avoid contamination of groundwater supplies and to ensure that the aquifer's water budget is kept within manageable balance.

Too little is presently known of groundwater recharge and discharge rates for the Kingshill aquifer. Although since 1992 DPNR/DEP has undertaken a more concerted groundwater planning effort with goals to answer some of these questions and to establish a wellhead protection program to avoid or minimize contamination, continued efforts are recommended.

WAPA, in conjunction with USGS and DPNR/DEP, should enhance its groundwater assessment and protection efforts, and work quickly to identify the Kingshill aquifer water budget so that a projected lifespan of the aquifer can be known and incorporated into public water supply policy. The adoption of a wellhead protection program should be given elevated priority. Specific wellhead protection measures, such as proper watertight seals on casings to prevent contamination, should be adopted under regulation without delay. All existing wells, including private wells, should be brought into permit compliance and flow-metered in order to more accurately determine the aquifer's water budget. All wells should be subject to specific capacity tests, with periodic review, to determine the appropri-

ate (sustainable) discharge rate for that well. Private wells should be subject to rationing procedures and special monitoring during times of drought.

To further protect groundwater supplies, a program of septic tank inspections and strictly applied standards for new tanks, should be established as soon as possible. This must include training on all aspects of design, construction, monitoring, and enforcement. Regulations, including tighter standards for septic tanks and wellheads, are recommended.

Subsurface contamination of the Kingshill aquifer through industrial spills or discharge is an ongoing problem that must be properly mitigated. *Ex post facto* clean-up operations are always possible, but they are costly and rarely achieve desired results. An EPA study of industrial sites similar to those found within the APC concluded that although significant mass removal of contaminants can be achieved through selective groundwater pumping and treatment, little success has been made anywhere in reducing concentrations to target levels. (Several authors suggest that restoration of water quality in many aquifers might not be achieved in less than 100 to 200 years of pumping (Abelson, 1990)).

Priority should be given to reductions of groundwater contaminants at their primary sources within the APC, and to achieve plume containment if necessary by pumping at a strategic series of wells. Further, industry should be required to publish public notice on spill events for oil and hazardous materials.

Public education is an essential component for reducing groundwater contamination. The public must be made aware that most forms of groundwater contamination are, as a practical matter, permanent. Modern and expensive technology may be used to reduce contamination to treatable levels with time. However, use of contaminated groundwater will involve continuous added costs to consumers to cover treatment processes.

Special attention should be given to HOVIC operations to ensure that the corporation is undertaking all that is possible to reduce groundwater contamination at their site. This should involve increased Government oversight in all environmentally sensitive aspects of HOVIC operations, and an agreed schedule for ongoing tank inspections and improvements to the extensive pipeline systems. Under no circumstances should discharge anywhere or of anything (including sea water) be permitted except into the permitted outfall.

Priority attention should be given to require that HOVIC extend its main outfall "intercepts" to service all areas within the refinery.

Nonpoint source pollution is a significant contributor to the overall degradation of nearshore environments in the U.S. Virgin Islands (Tetra Tech, 1991b). Although the islands have no perennial streams or rivers, episodic events of intense rainfall deliver pulses of fresh water laden with sediments, nutrients, organic matter, and potentially toxic chemicals to nearshore receiving waters. Control of nonpoint source pollution may have significant positive effects on pristine and otherwise valuable marine habitat. The following list of recommendations for nonpoint source discharge control is adapted from Tetra Tech, Inc. (1991b):

1. separate storm drainage channels and sanitary sewers;
2. collect and treat Combined Sewer Overflows (CSOs), using infiltration trenches/basins or chemical or filtration treatment systems;
3. regulate land use practices and behaviors that contaminate stormwater (e.g., waste oil disposal, establishment of green or infiltration areas on a portion of developed property, establishment of impervious surface limits);
4. impose routine inspection and management requirements for on-site (septic tank) wastewater systems;
5. develop treatment options for stormwater (e.g., detention basins, grassy swales, vegetation buffers, artificial wetlands);
6. implement source control practices such as street sweeping;
7. implement soil conservation measures on all construction projects (e.g., vegetation buffer zones, retention basins, silt-curtains, diversion ditches, etc.);
8. establish performance standards to reduce the total area of non-porous surface materials used on access roads, driveways, and parking areas; encourage the use of permeable materials such as "grassphalt", gravel, or appropriate vegetation; regulate agricultural land use practices (e.g., tilling, burning, land clearing);
10. reduce chemical fertilizer and pesticide use through integrated pest-management techniques and use of organic fertilizers and treated wastewaters as fertilizer inputs; and
11. develop stringent sanitary landfill practices where groundwater leachate and floatable debris may impact nearshore water quality of groundwater supplies.

The airport, the sewage treatment plant, and the municipal landfill should all be brought into compliance with the Clean Water Act. *Stormwater management plans need to be developed, and discharge permits issued containing specific effluent standards. Treatment of stormwater runoff should be effected, including the use of oil/water separators, as appropriate.*

Wastewater

Frequent breakdowns of St. Croix's aging sewage collection and treatment system have resulted in numerous bypass operations to-date with associated threats to public safety, health, and welfare (section 2.6.3). Of legitimate concern are similar impacts on plant and animal communities.

An operations and maintenance plan for the public wastewater system of St. Croix should be prepared and funded to achieve effective rehabilitation of equipment, to provide for an efficient and well-stocked spares inventory, and to provide effective training for system operators. It should be recognized that the operation of a public wastewater system is as much a problem of human resource management as it is a problem of aging equipment and technologies. Performance based incentive structures need to be developed, and individual accountability (to the public) established throughout the public works system, especially for key positions such as plant manager. Public notice procedures should be strictly followed during bypass operations to enhance public trust and to minimize threats to public safety and health.

The long-term effects of offshore discharge of municipal wastewater are not well understood. Where effluent is carried back into nearshore environments, or where effluent makes contact with offshore coral reefs or seagrass systems, sub-lethal effects may occur which may result in overall reduced

biological productivity. As human populations expand and nutrient loading of offshore waters increases, eutrophication of offshore waters may occur (Tetra Tech, 1991b). In conjunction with the USEPA, relevant agencies of the USVI Government should consider the long-term outlook for ocean discharge, and develop nutrient loading, concentration, and sedimentation limits for outfalls within effluent reach of coral reefs and seagrass beds. *Long-term strategies to reduce offshore discharges may include land application of treated wastewaters for agricultural purposes* (Tetra Tech, 1991b).

Industrial wastewater discharges may also affect marine biological communities through the discharge of toxic or sub-lethal concentrations of organic chemicals and heavy metals. Sub-lethal effects of industrial wastes on marine organisms are not well understood, but mitigation measures should focus on source reduction wherever possible. *Efforts should be made to promote changes in industrial processes and encourage recycling of industrial wastes.*

Thermal effluents from power plants and other industrial processes, can result in adverse impacts to biological communities, both through temperature intolerance and the use of chemicals used to reduce biofouling of cooling systems. Energy conservation efforts to reduce demands on public power plants will pay dividends for the coastal environment. In addition, thermal effluents should be adequately cooled, and chemicals that are used to reduce biofouling evaluated for their possible toxic or sub-lethal effects on the marine environment.

Impacts from the operation of desalination plants result from the discharge of warm hypersaline brine and associated chemicals used to reduce biofouling in the cooling systems. The type of desalination process used, the volume of water undergoing treatment, and the location of discharge outfalls determine the type and severity of environmental impact. As with effluents from power plants, a reduction (through conservation measures) in the volume of water undergoing treatment may in the long-term pay dividends for the protection of distinctive or valuable marine habitat. At the very least, hypersaline effluents should be adequately diluted with fresh sea water and cooled prior to discharge.

Air

Future industrial development proposals, or expansion of existing facilities, should be required to assess the cumulative impact of any new emissions against an established standard, presumably the National Ambient Air Quality Standards. An ongoing area-wide air quality testing program to determine if NAAQS are being met should be commenced.

There is a need for more Government enforcement capability with respect to the operations of small businesses, such as asphalt plants, dry cleaners, and auto repair and paint shops. The cumulative impact from these diverse sources can be substantial, and perhaps more serious to residents in the immediate vicinity of these operations. Large source emissions are dealt with by federal and territorial authorities, while these smaller source emissions are generally left to local authorities for monitoring and enforcement. Monitoring and enforcement of the growing number of small businesses should be assessed(section 4.4).

The major industries in the area are continuing to strive for improvements to reduce direct and fugitive air emissions. Further improvements are possible, including the requirement for public notification on any emergency or accidental emission. HOVIC, for example, should be required to perform fire

training exercises on days when no rain is imminent (particulates settle out faster during rain), in addition to some form of public notification if there is any deviation from schedule.

A risk assessment should be conducted regarding air-borne dust emissions and their effect on household (cistern) drinking water supplies. The public should be notified of any precautionary measures that may be taken, such as routine cleaning of cisterns or the use of a particular type of filtration system, or whether in fact there is no cause for concern.

Noise

Specific adverse impacts to surrounding communities from noise emanating from the industrial area have not been identified. Environmental assessments conducted to-date have not addressed the question of cumulative noise impacts with respect to any target (human or wildlife) sub-population.

Preparers of future environmental assessment reports should be required to assess cumulative noise impacts as they may affect particular target communities within an identifiable radius (or down wind corridor) of the proposed development.

Biological Resources

Manning Bay (including the lower reaches of Bethlehem Gut and the area south of the VIALCO cooling ponds), Ruth Cay, and the Billy French Ponds are important remaining habitats in the Southshore Industrial Area. Significant mangrove communities exist from west of Alucroix Channel to Anguilla Estate, and along the Manning Bay shoreline, including the lower reaches of Bethlehem Gut. Some of these areas, although not in the most pristine condition, are good candidates for wetland restoration efforts. This is especially true for the area between VIALCO and HOVIC (Area "C"), as it appears that with a simple restoration of hydrology to at least part of this area, a significant regrowth of mangroves could be facilitated. Soil testing should be conducted for "Area C", to determine if PCBs or other contaminants are present.

In addition, the Billy French Ponds provide for critical roosting and feeding habitat for several species of birds (section 2.4.1). The Billy French Ponds are two of the few ponds on St. Croix which remain wet throughout the year, and thus provide important refuge for waders, waterfowl, and shorebirds that remain here year-round. The ponds offer large trees as critical roosting habitat for several bird species. Beaches at Canegarden Bay are sea turtle nesting sites for the Hawksbill sea turtle.

It is recommended that designation as Significant Natural Areas be made of the shoreline area west of Alucroix Channel to Anguilla Estate (south of VIALCO cooling ponds), the Manning Bay shoreline, including the lower reaches of Bethlehem Gut, and the Billy French Ponds. These should be protected as wildlife sanctuaries, with specific human use categories developed and enforced by DPNR/DEE. The wild dog population at Billy French Ponds should be extirpated as soon as possible, and the residential access road which skirts the eastern portion of the eastern pond should be relocated so that it does not alter surface hydrology.

The mangrove areas south of VIALCO cooling ponds and east of VIALCO should be investigated for restoration potential, which may include restoring the natural hydrology of the two areas (in the

former instance, possibly accomplished by reconstructing the pond's floodgates to allow for discharge along the southern dike). It is recommended that the area east of VIALCO ***not*** *be used for expansion of the VIALCO tailings piles, but should be seen as a habitat worthy of rehabilitation and enhancement.*

The Fig Tree pump station should be targeted for priority rehabilitation efforts to ensure that sewage bypass operations are absolutely minimized. In the event that bypass is necessary, however, water quality within the Fig Tree Hill Gut should be monitored and diverted from entering the Billy French Ponds if found to be of less than acceptable quality. It should be kept in mind, however, that freshwater inflows to the ponds are important for maintaining natural salinity balances (and for nutrient input).

A site-specific wetlands management plan should be developed for the Southshore Industrial Area. The plan should accomplish as a minimum the following:

1. *establish a legal territorial definition of wetlands (in consultation with the responsible federal agencies);*
2. *delineate existing wetland boundaries based on selected criteria;*
3. *characterize individual wetlands for functions and values;*
4. *determine baseline status and trends;*
5. *devise an effective management framework;*
6. *develop mitigation and restoration targets; and*
7. *delineate agency and private citizen responsibilities.*

Adequate shoreline setback standards with no allowable bulkheading in mangrove areas should be implemented to allow for future landward migration of wetlands in the event that sea level rises.

Ruth Cay should be targeted for increased surveillance by DPNR/DEE to monitor human activities on and around the cay, especially during the closed Least Tern nesting season (May through September). Hunting should be officially prohibited year-round. Only non-destructive forms of human activities should be allowed (i.e., research and passive recreational activities like bird watching, photography, etc).

Coral reefs, seagrass beds, and mangroves interact in several important ways and must be managed as an ecological unit. Healthy stands of mangroves assist to trap sediments which can damage seagrass beds and coral reefs. In addition, mangroves provide valuable habitat for several aquatic and wildlife species. It is well documented that certain species of fish migrate from seagrass beds to feed near coral reefs in the morning, and return to the seagrass beds at night.

Such short-term feeding migrations are but one type of interaction between these communities that establish their interdependency. Life-history migrations also occur, as for example when juvenile lobsters settle in seagrasses and mangrove prop roots early in their development, then migrate to coral reefs as they mature. Seagrass blades (especially those of *Syringodium*) float for several days after detachment by rough seas or by grazing animals such as parrotfishes and sea turtles, before decomposing and becoming an important nutrient source for benthic communities below (IRF, 1986). In combination with organic nutrients supplied by the mangrove system, these "by-products" of the

seagrass/mangrove system should be recognized as significant contributors to the energy needs of coral reefs.

Bioaccumulation of pathogens or heavy metals in fish which inhabit the Alucroix Channel should be studied and public health effects determined. The Channel is utilized by subsistent and recreational fishermen, and a *Tilapia* aquaculture project is planned for the Channel. This major industrial discharge channel may not be the most suitable place for such a pilot project involving the sale of fish at local markets.

Cultural Resources

DPNR/Division of Archaeology and Historic Preservation should work to identify the most significant cultural resources worthy of protection within and adjacent to the APC, and establish a priority acquisition list for possible future acquisition. At the same time, funding mechanisms should be explored to allow for such acquisition. An alternative to acquisition is the encouragement of private sector cooperation in conservation measures, stimulated by the appropriate incentive mechanisms offered by Government.

In the event that cultural sites are to be removed or damaged as a component of a proposed development, mitigation measures should be designed and fully enforced, and should include the requirement for a qualified archaeologist or historian (as appropriate) to direct such mitigation and/or data recovery efforts.

Although not within the APC boundary, the Great House at Estate Whim is an important cultural resource and tourist destination worthy of utmost protection. Situated to the west, and down wind, of the APC, its outside gardens and museum could be impacted by worsened air quality within the APC. This possibility should be explored as part of the environmental assessment process for proposed developments.

Transportation

Marine transportation appears to be functioning well in the southshore area, with collision risk relatively low.

Solid Waste Management

Improved management and selection of municipal solid waste landfill sites are issues facing all three islands in the Territory. Groundwater leachate at municipal solid waste landfills may adversely impact nearshore environments and groundwater resources with nutrients and toxic chemicals. The following recommendations are adapted from Tetra Tech (1991b):

1. promote waste reduction through recycling and reuse;
2. promote composting of organic wastes and use as fertilizer;
3. investigate landfill sites for potential contamination and implement remediation measures where necessary;
4. develop regulations for siting, operating, and maintaining solid waste landfills;

5. require that solid waste landfills receive the necessary permits from the proper authorities, including stormwater discharge (TPDES) permits as necessary;
6. encourage source reduction and develop programs for hazardous waste disposal (e.g., community collection centers); and
7. investigate hazardous waste sites for potential contamination and implement remedial measures where necessary.

Until an alternative site for the St. Croix municipal solid waste landfill can be located, the Anguilla landfill should be upgraded to meet new municipal solid waste landfill criteria (40 CFR, section 258), including the establishment and maintenance of a protective berm (mounded soil with stabilizing vegetation) on the seaward side of the landfill. The existing southern edge of the landfill should be pushed back away from the coast, to a minimum distance of 100 meters and further encroachment towards the coast strictly prohibited. The DPW should be required to submit application to DPNR for a TPDES permit as part of new stormwater management regulations under the Clean Water Act.

In light of coastal zone management Best Management Practices, and especially in light of existing bird and smoke aviation safety concerns at the landfill's present location, DPW, in conjunction with DPNR, should reevaluate plans for the siting of an integrated solid waste management and materials recovery center at this coastal location. The search for an alternative site for the landfill should be given priority attention.

4.3 Institutional Development

Successful management of the Southshore Industrial Area will come about quicker and with more lasting results if the local community is drawn into the process in a way that promotes self-responsibility and accountability by the various user groups. The non-governmental community (the various associations, churches, and other commercial and philanthropic organizations) should be called upon to address certain specific components of the overall management framework, and even to finance certain elements that will have obvious payback benefits to the community.

5. CONCLUSION

The Southshore Industrial Area and its watershed is St. Croix's fastest growing area for residential, commercial, and industrial purposes. The island's human population has increased from about 15,000 in 1960 to about 50,139 in 1990, and a majority of these new residents have settled or work within the APC and its watershed. Careful planning attention is needed if the adjacent siting of incompatible land uses is to be avoided, and if Government is to successfully encourage mixed-use infilling along established and planned public utility and service routes to achieve a least-cost growth scenario.

Land use planning must be comprehensive in its approach, with consideration of projected recreational, open space, and agricultural needs of the growing populace. Thus, high density residential and commercial land use must be achieved if future options are to be left open for these other, often forgotten land use needs.

Groundwater use is considerably higher on St. Croix than on St. Thomas and St. John. Much of St. Croix's groundwater is pumped from the Kingshill aquifer located beneath the south central portion of

the island, which includes the Southshore Industrial Area. Efforts to protect aquifer recharge areas are of paramount importance and must not be compromised at any time. In this regard, subsurface hydrocarbon contamination at HOVIC, and the company's progress and difficulties with recovery efforts, should be a matter of public record, dialogue, and understanding.

The preservation of remaining natural areas (both terrestrial and marine) is likewise of great importance to both wildlife and humans alike. The Southshore Industrial Area, despite its history of physical and biological alteration, continues to support valuable habitat for several threatened or endangered species. The Manning Bay area (especially the lower reaches of Bethlehem Gut), the Billy French Ponds, and Ruth Cay should receive priority attention with respect to impact assessment of future developments, and official designation as Significant Natural Areas.

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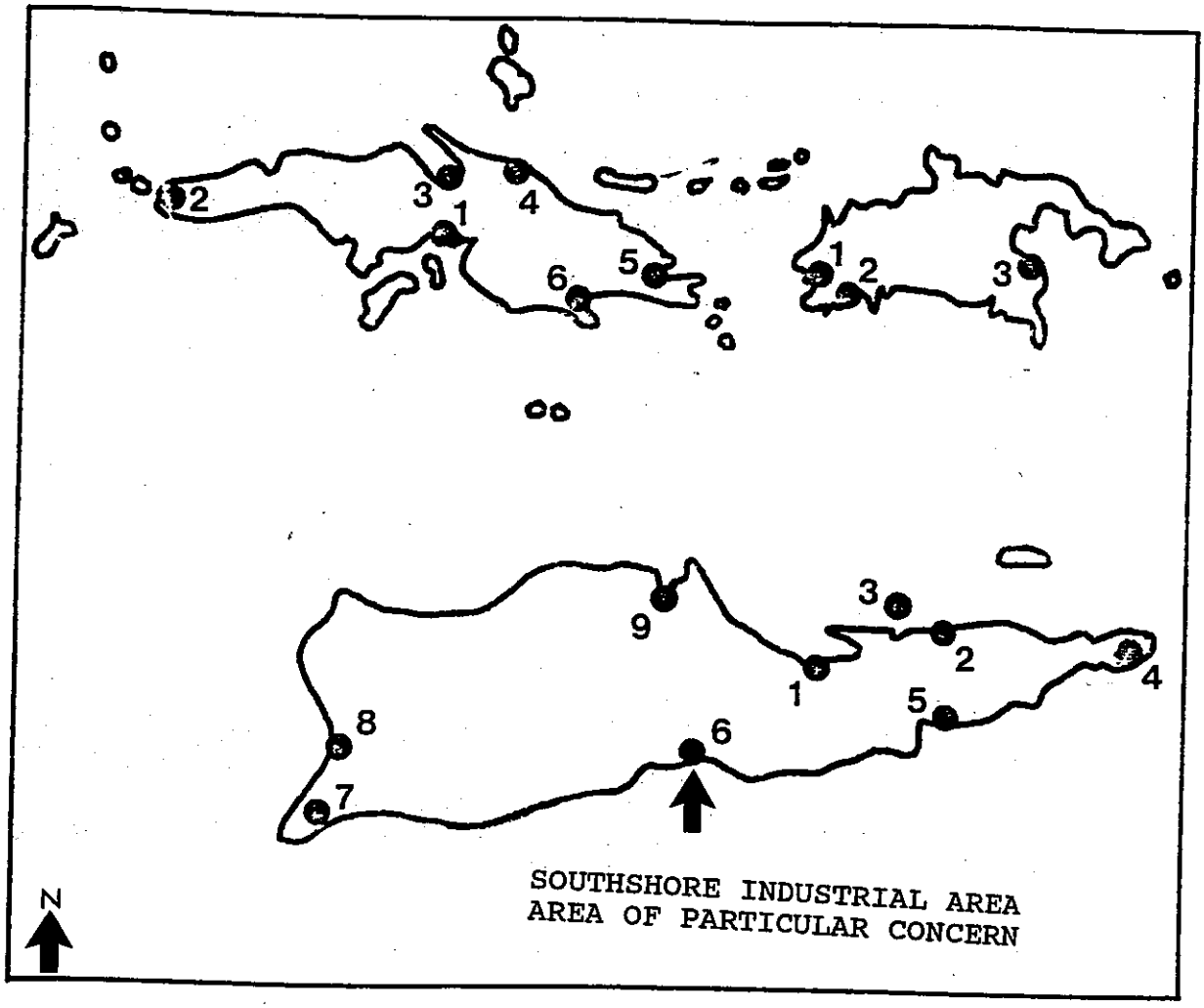
AREAS OF PARTICULAR CONCERN



AREAS OF PARTICULAR CONCERN

St. Thomas

1) St. Thomas Harbor and Waterfront
2) Botany Bay (APR)
3) Magens Bay and Watershed
4) Mandahl Bay (APR)
5) Vessup Bay - East End
6) Mangrove Lagoon - Benner Bay (APR)

St. John

1) Enighed Pond - Cruz Bay
2) Chocolate Hole - Great Cruz Bay (APR)
3) Coral Bay (APR)

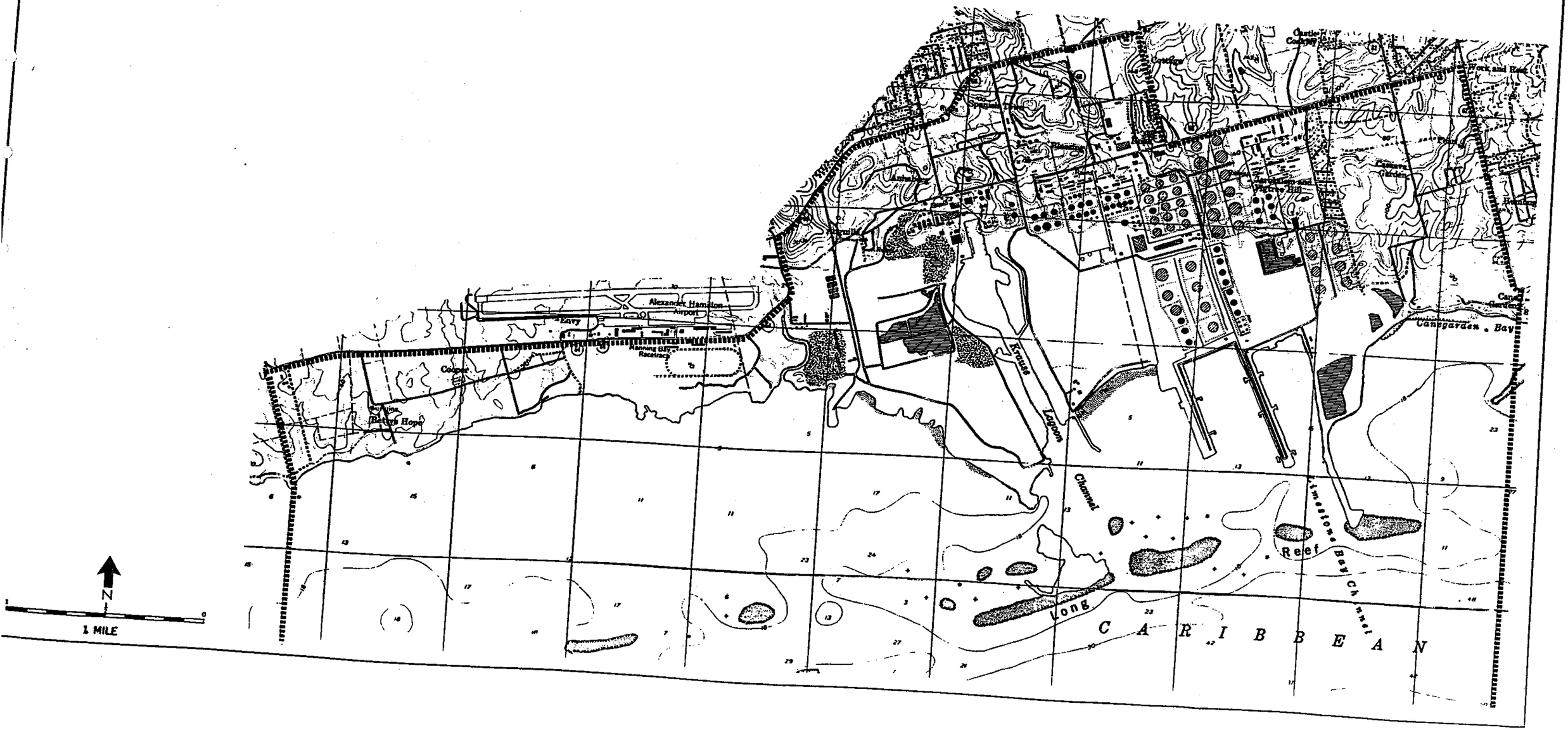
St. Croix

1) Christiansted Waterfront
2) Southgate Pond - Chenay Bay (APR)
3) St. Croix Coral Reef System (APR)
4) East End (APR)
5) Great Pond and Great Pond Bay (APR)
6) Southshore Industrial Area
7) Sandy Point
8) Frederiksted Waterfront
9) Salt River Bay and Watershed (APR)

Figure 1
Regional APC Map
Adapted from: USDOC, 1979

SOUTHSHORE INDUSTRIAL

Figure 2
APC Boundary Map
Base map adapted from: USGS, 1982
Island Resources Foundation, 1992



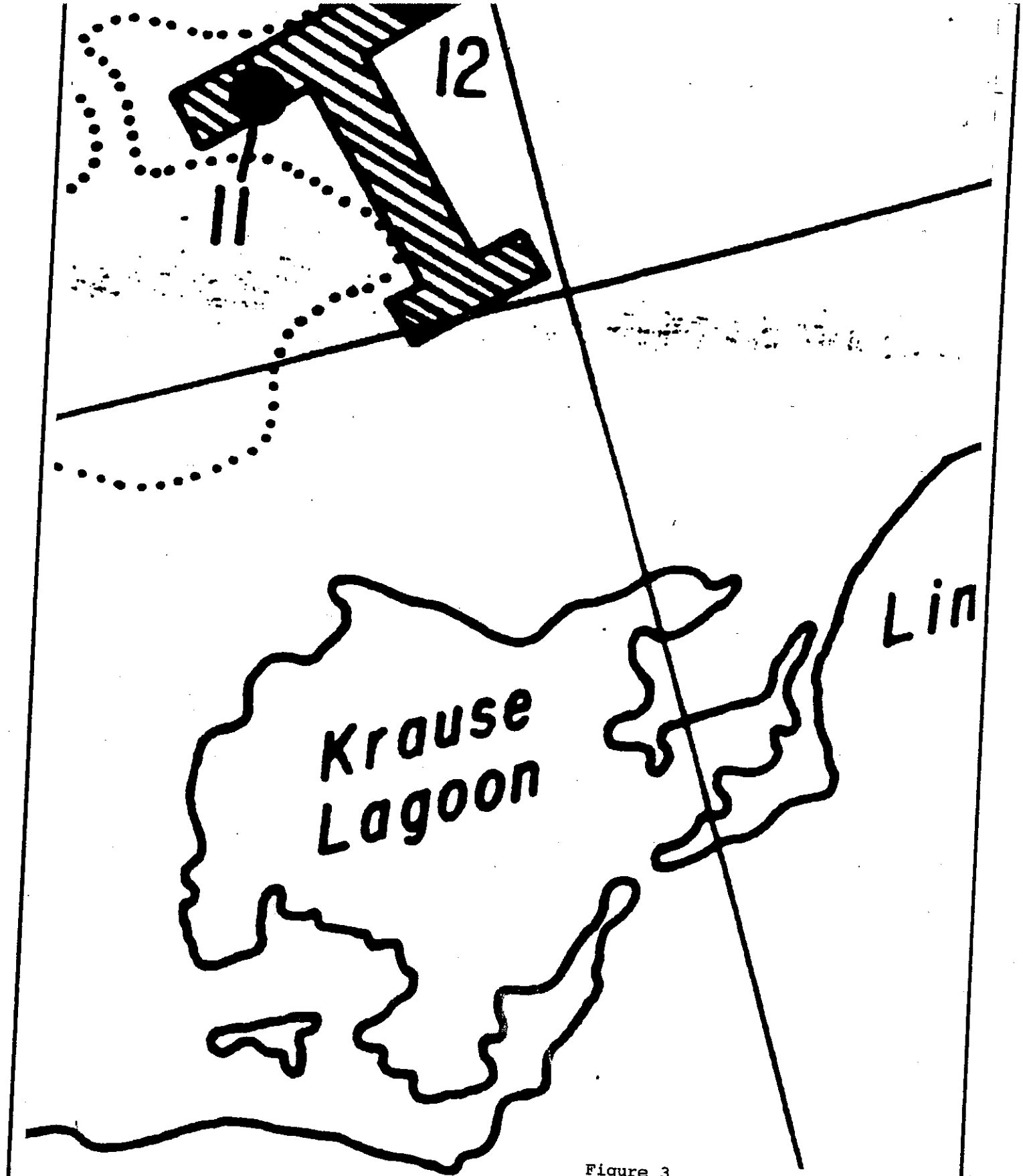


Figure 3
Krause Lagoon Prior to Dredge and Fill Activities of 1960s
Adapted from: Jordan, 1975
Island Resources Foundation, 1992

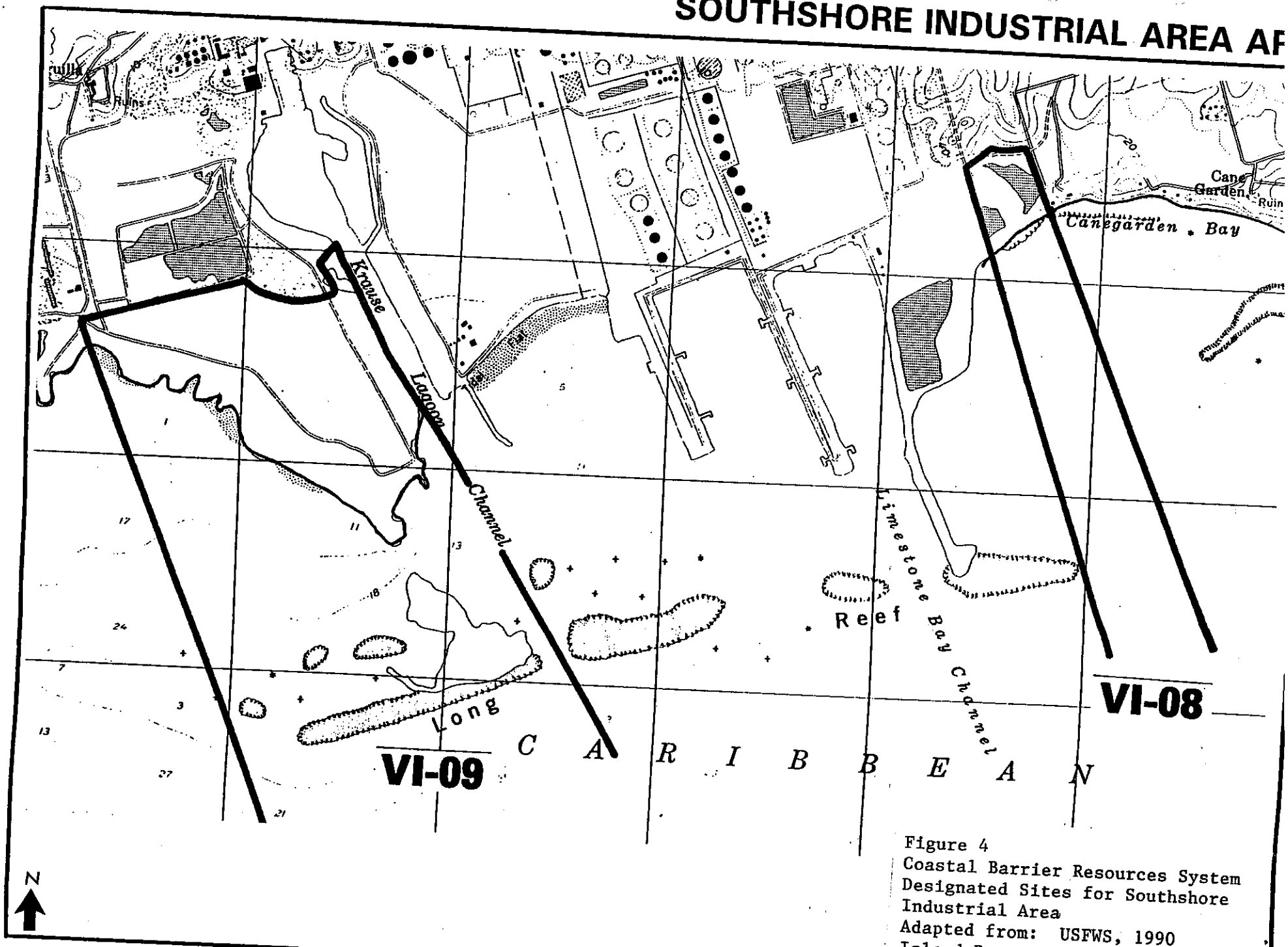


Figure 4
Coastal Barrier Resources System
Designated Sites for Southshore
Industrial Area
Adapted from: USFWS, 1990
Island Resources Foundation, 1993

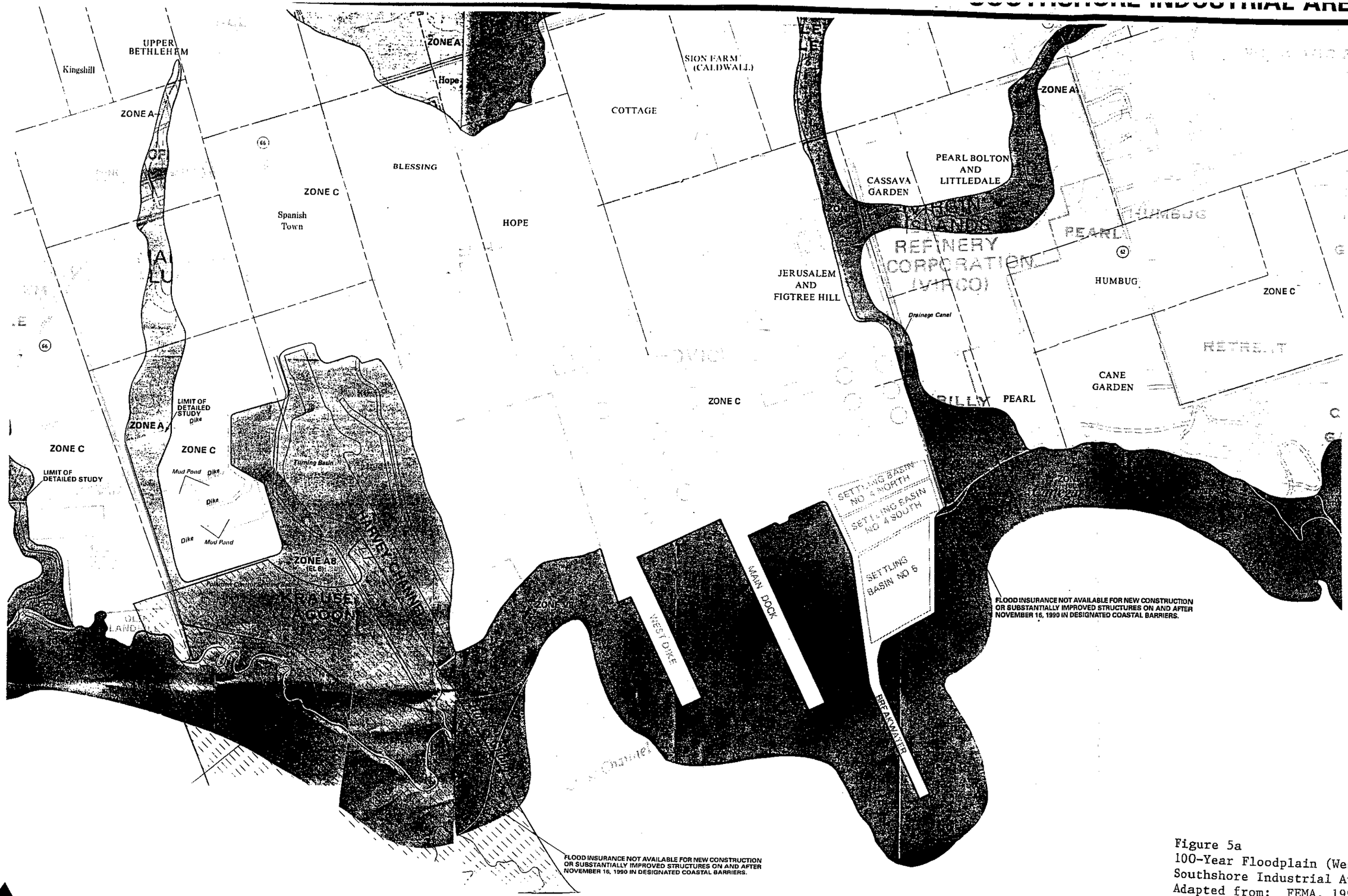


Figure 5a
100-Year Floodplain (West)
Southshore Industrial Area
Adapted from: FEMA, 1992
Island Resources Foundation, 1993

KEY TO MAP

- 100-Year Flood Boundary — ZONE B
- 500-Year Flood Boundary
- Zone Designations* — ZONE A / ZONE A
- 100-Year Flood Boundary — ZONE B
- 500-Year Flood Boundary
- Base Flood Elevation Line With Elevation in Feet** — 513
- Base Flood Elevation in Feet Where Uniform Within Zone** — (EL 987)
- Elevation Reference Mark — RM7×
- Estate Boundary
- River Mile — •M1.5

UNDEVELOPED COASTAL BARRIERS†

Identified 1983	Identified 1990	Otherwise Protected Areas

†Coastal barrier areas are normally located within or adjacent to special flood hazard areas

**Referenced to Mean Sea Level

*EXPLANATION OF ZONE DESIGNATIONS

ZONE	EXPLANATION
A	Areas of 100-year flood; base flood elevations and flood hazard factors not determined.
AO	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; average depths of inundation are shown, but no flood hazard factors are determined.
AH	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; base flood elevations are shown, but no flood hazard factors are determined.
A1-A30	Areas of 100-year flood; base flood elevations and flood hazard factors determined.
A99	Areas of 100-year flood to be protected by flood protection system under construction; base flood elevations and flood hazard factors not determined.
B	Areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than one (1) foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood. (Medium shading)
C	Areas of minimal flooding. (No shading)
D	Areas of undetermined, but possible, flood hazards.
V	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors not determined.
V1-V30	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors determined.

INITIAL IDENTIFICATION:
FEBRUARY 25, 1977

FLOOD HAZARD BOUNDARY MAP REVISION:
NONE

FLOOD INSURANCE RATE MAP EFFECTIVE:
OCTOBER 15, 1980

FLOOD INSURANCE RATE MAP REVISIONS:

March 18, 1987 - to add special flood hazard areas, and to change zone designations.

August 3, 1992 - to add undeveloped coastal barriers and otherwise protected areas.

THE ESTATE BOUNDARIES ON THIS MAP PANEL ARE FOR REFERENCE PURPOSES ONLY. THEY WERE PROVIDED BY THE DISASTER PREPAREDNESS OFFICE, CIVIL DEFENSE AND EMERGENCY SERVICES, OFFICE OF THE GOVERNOR THE LOCATION OF THE BOUNDARIES ARE APPROXIMATE WITH RESPECT TO THE CULTURE SHOWN ON THIS MAP.

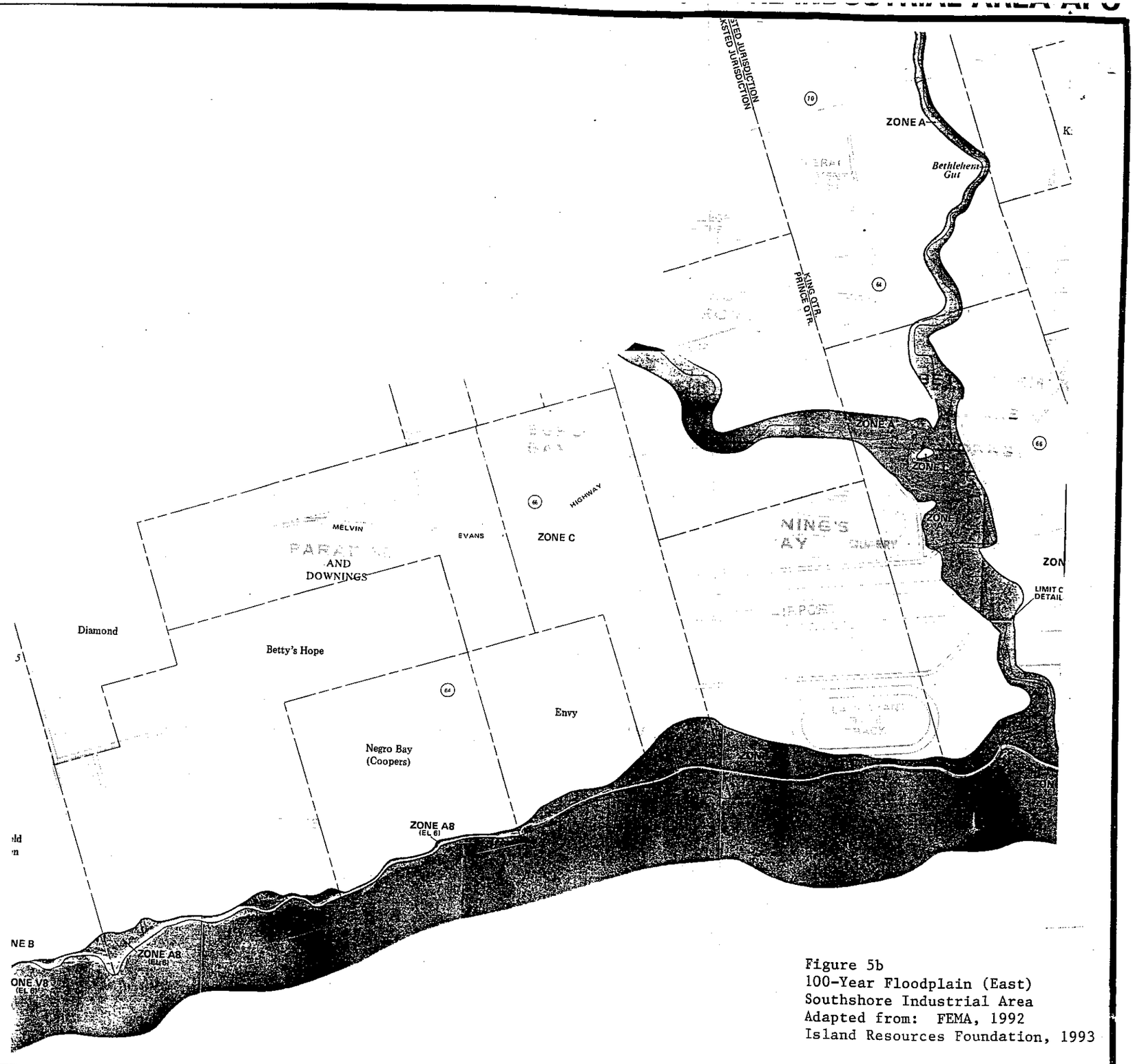


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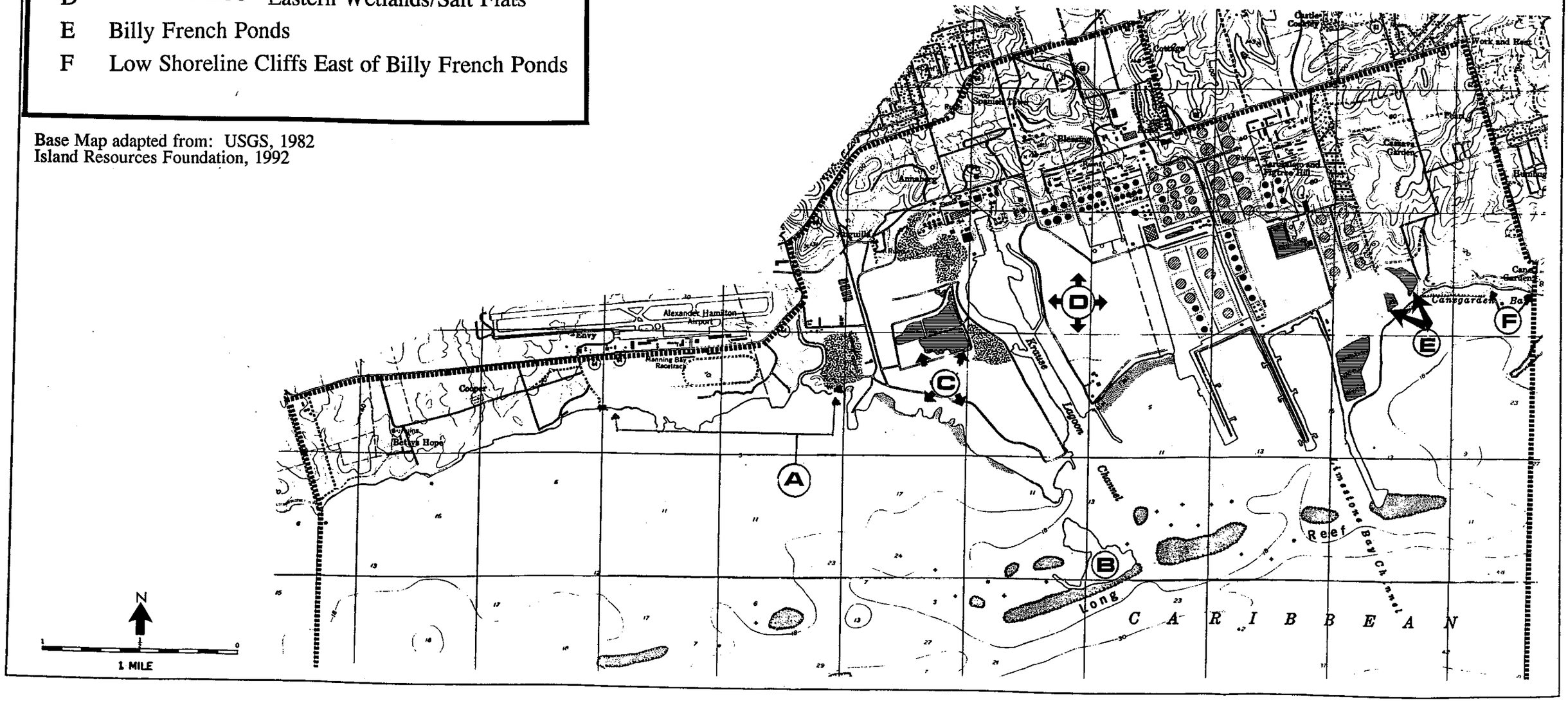
Figure 5b
100-Year Floodplain (East)
Southshore Industrial Area
Adapted from: FEMA, 1992
Island Resources Foundation, 1993

SOUTHSHORE INDUSTRIAL

FIGURE 6 SIGNIFICANT NATURAL AREAS

A	Manning Bay
B	Ruth Cay
C	VIALCO Pond and Mangroves
D	VIALCO Eastern Wetlands/Salt Flats
E	Billy French Ponds
F	Low Shoreline Cliffs East of Billy French Ponds

Base Map adapted from: USGS, 1982
Island Resources Foundation, 1992



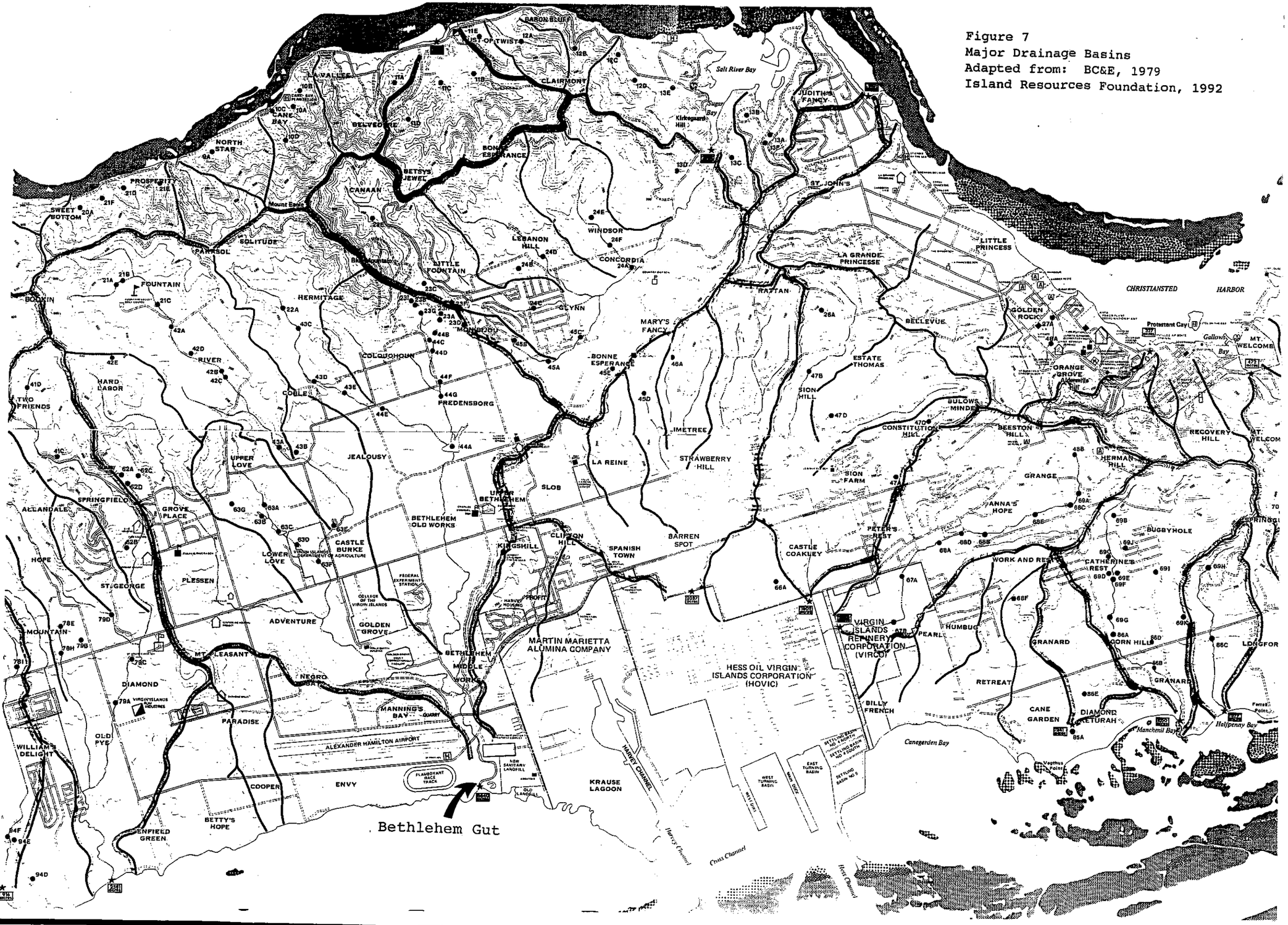
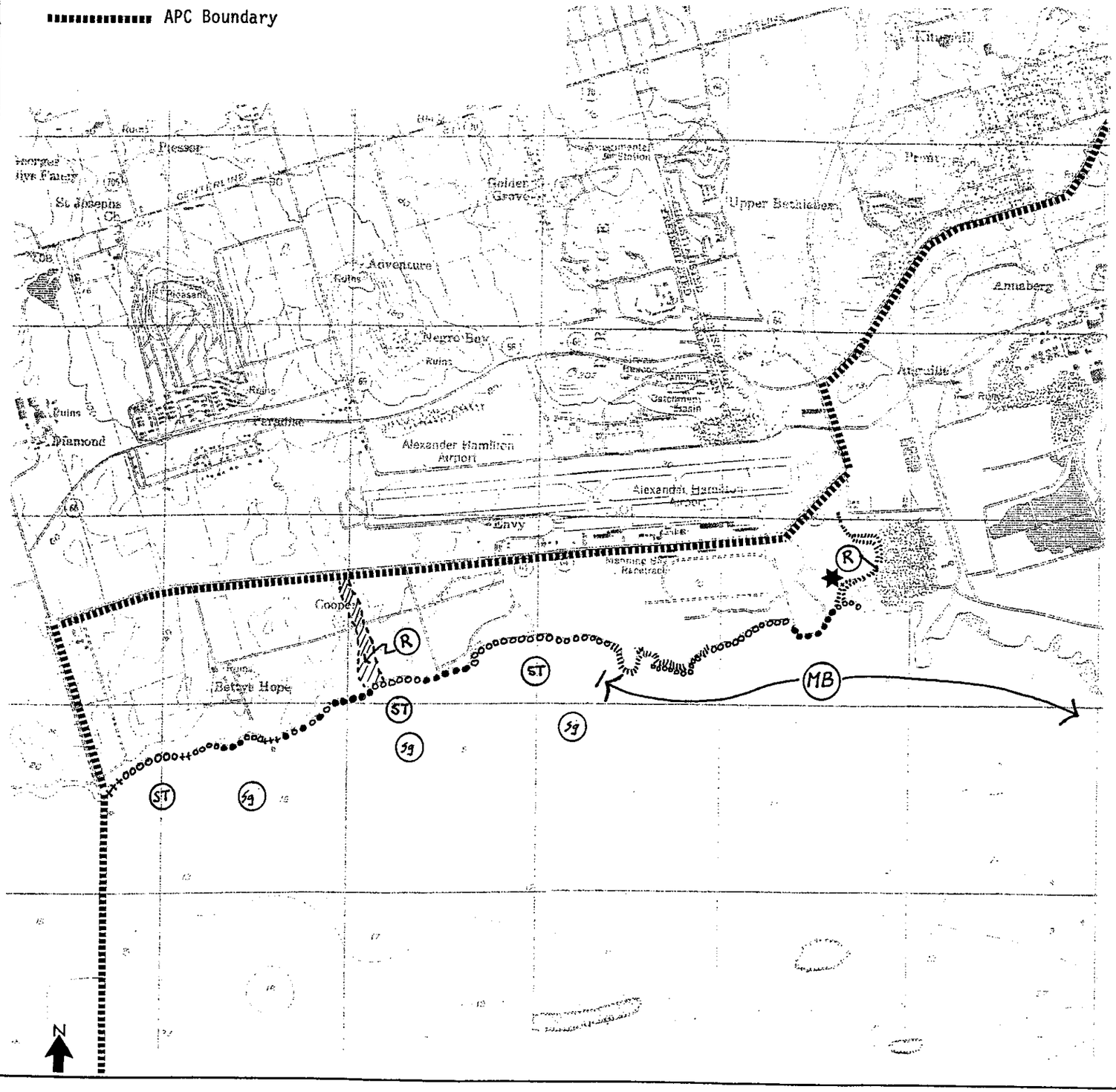


Figure 7
Major Drainage Basins
Adapted from: BC&E, 1979
Island Resources Foundation, 1992

SOUTHSHORE INDUSTRIAL (West)

APC Boundary



PHYSICAL AND BIOLOGICAL FEATURES

- R — Riverine habitat
- Fine-grained sand beaches
- Mixed sand and gravel beaches
- Exposed rocky shores
- Mangrove shoreline
- (Sg) — Seagrass beds
- (ST) — Sea turtles (nesting on sand beaches)
- (MB) — Marine birds (mainly; Brown Pelican, Brown booby, Royal tern and Least tern)
- ★ — Important wildlife habitat

Figure 8a
Biological and Physical Resources (West)
Base map adapted from: USGS, 1982
Island Resources Foundation, 1992

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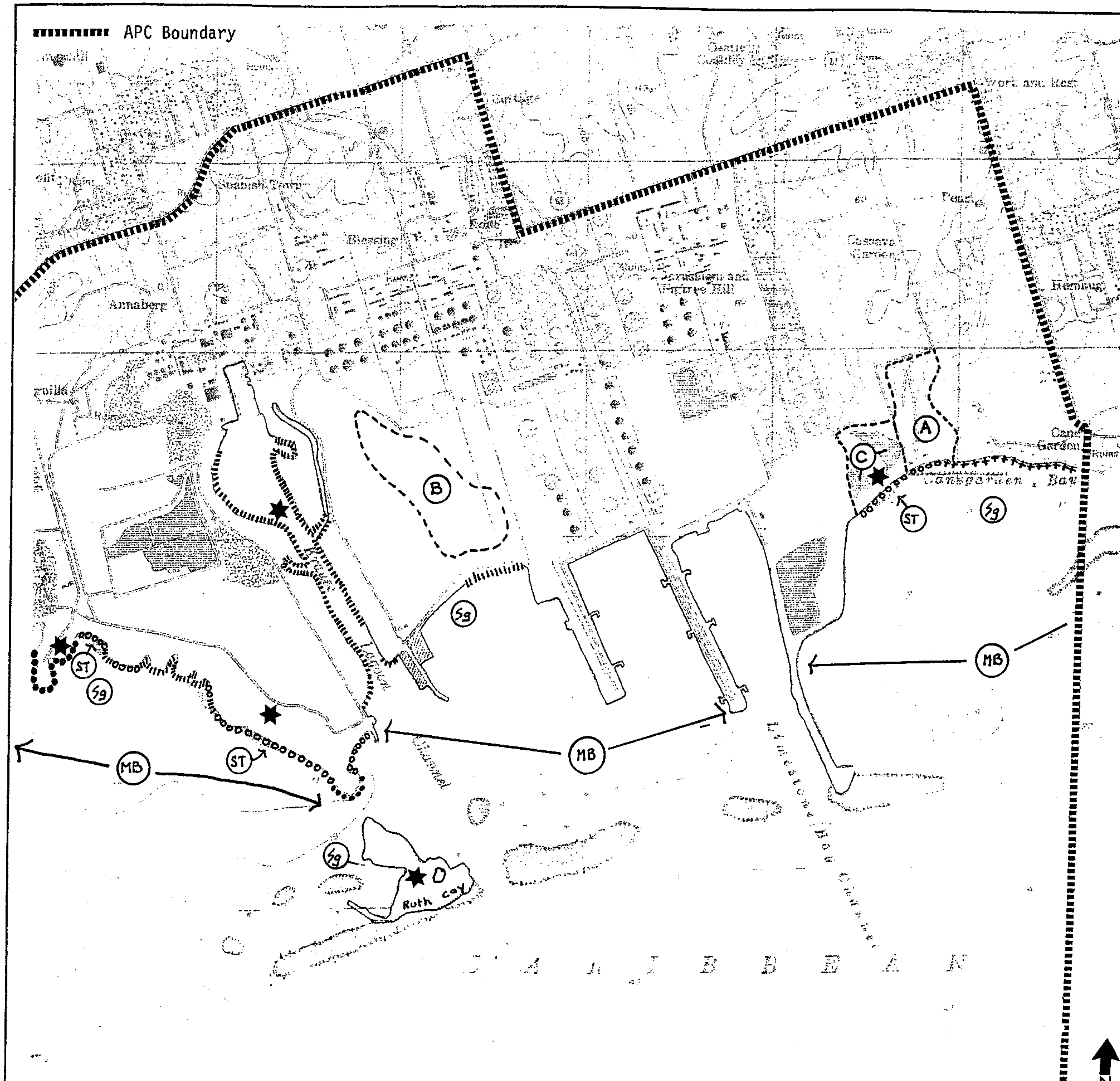
SOUTHSHORE INDUSTRIAL (East)



PHYSICAL AND BIOLOGICAL FEATURES

A	Deciduous woodland
B	Salt flat
C	Salt pond
oooo	Fine-grained sand beaches
••••	Mixed sand and gravel beaches
+++++	Exposed rocky shores
IIIIIIIII	Mangrove shoreline
Sg	Seagrass
ST	Sea turtles (nesting on sand beaches)
MB	Marine birds (mainly; Brown pelican, Brown booby, White-tailed tropicbird, Royal tern and Least tern)
★	Important wildlife habitat

Figure 8b
Biological and Physical Resources (East)
Base map adapted from: USGS, 1982
Island Resources Foundation, 1992

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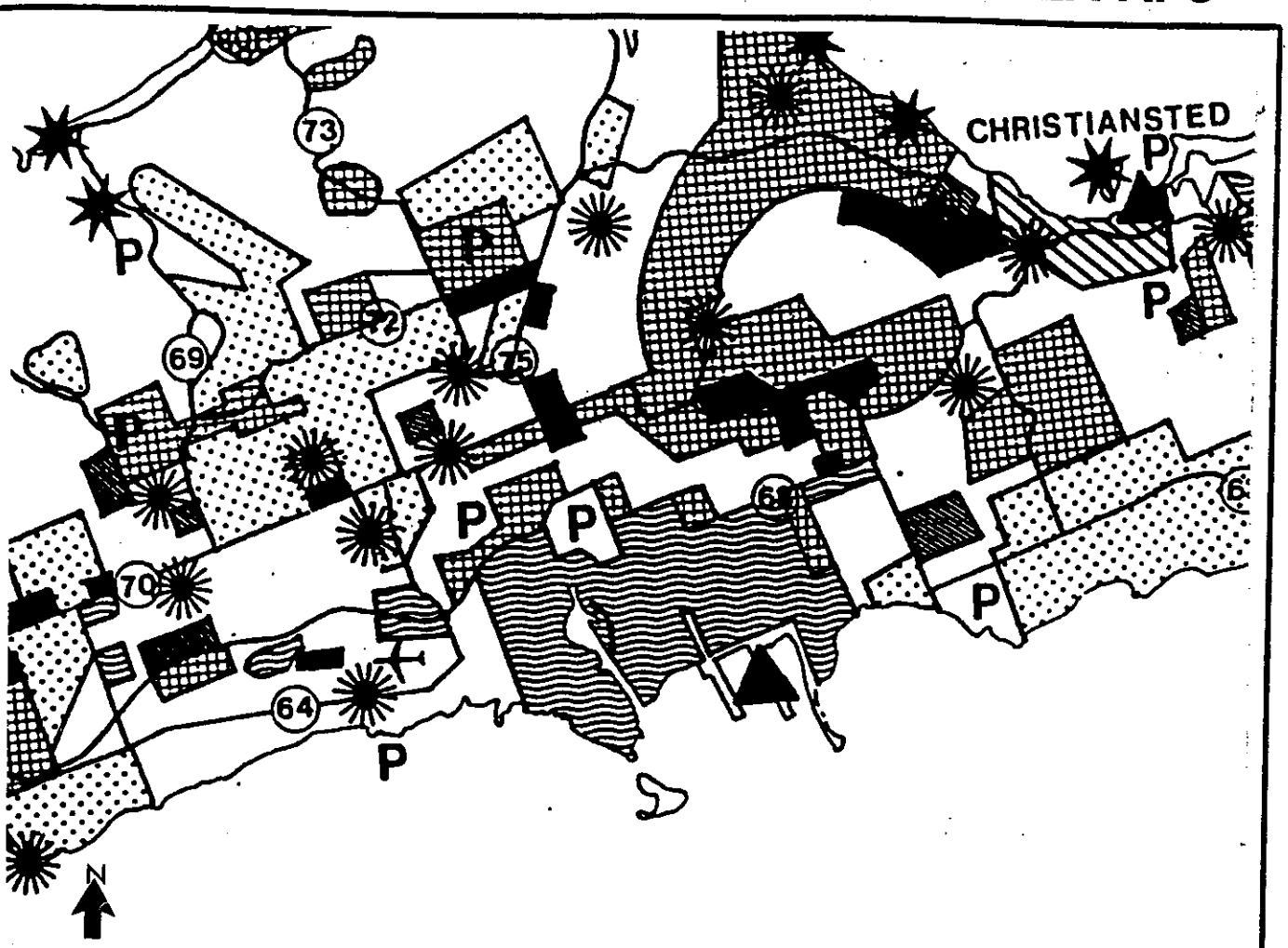


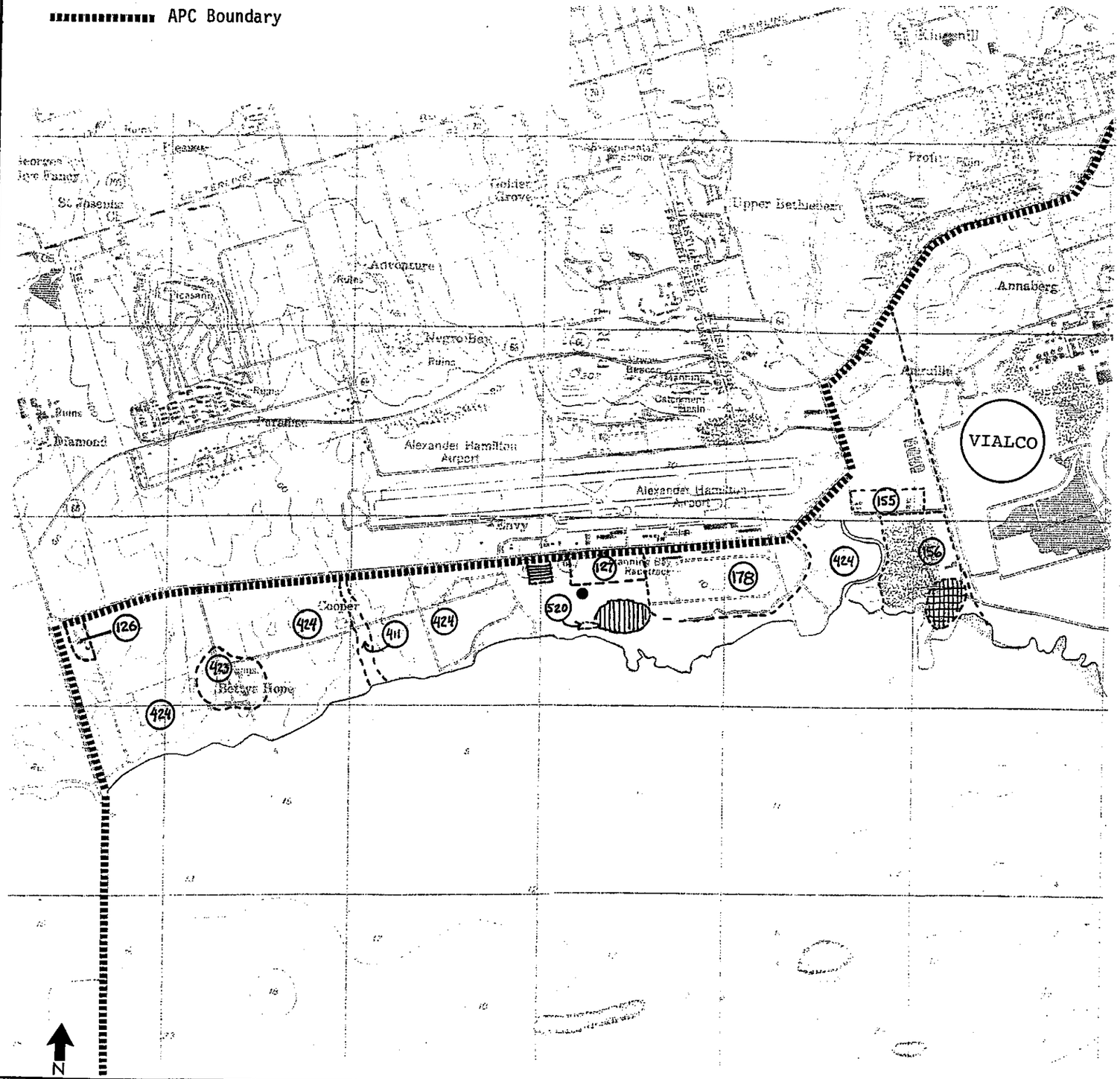
LEGEND

- LOW / MEDIUM DENSITY RESIDENTIAL
- HIGH DENSITY RESIDENTIAL
- COMMERCIAL
- URBAN
- HOTELS / RESORTS
- PUBLIC FACILITIES
- MARINAS / DOCKS
- PARKS / RECREATION
- UNDEVELOPED
- AGRICULTURE
- INDUSTRIAL / MANUFACTURING

Figure 9
Generalized Existing Land Use
Base map adapted from: Strategic Planning Group, 1991, which was adapted from Island Resources Foundation, 1989.
Island Resources Foundation, 1992

SOUTHSHORE INDUSTRIAL (West)

APC Boundary



LAND USE

Commercial & Services

- 126 Oil & Gas storage facility
- 127 Mixed commercial & services

Utilities

- 155 Sewage treatment plant
- 156 Solid waste disposal
- ● Dump site

Recreational

- 178 Race Track

Land Cover

- 411 Streamside woodland
- 423 Woodland
- 424 Mixed woodland & brush
- 520 Salt pond

Proposed future land uses

National Guard Warehouse (to be constructed on Port Authority property)

Four (4) acres of wetland to be "created" as compensatory mitigation for WAPA power plant project

Site of Dept. of Public Work's proposed scrap metal/solid waste management facility (14 acres); to be leased to private sector for operation

Figure 10a
Land Use within APC (West)
Base map adapted from: USGS, 1982
Island Resources Foundation, 1992
Classification System: Teytaud, 1981

N

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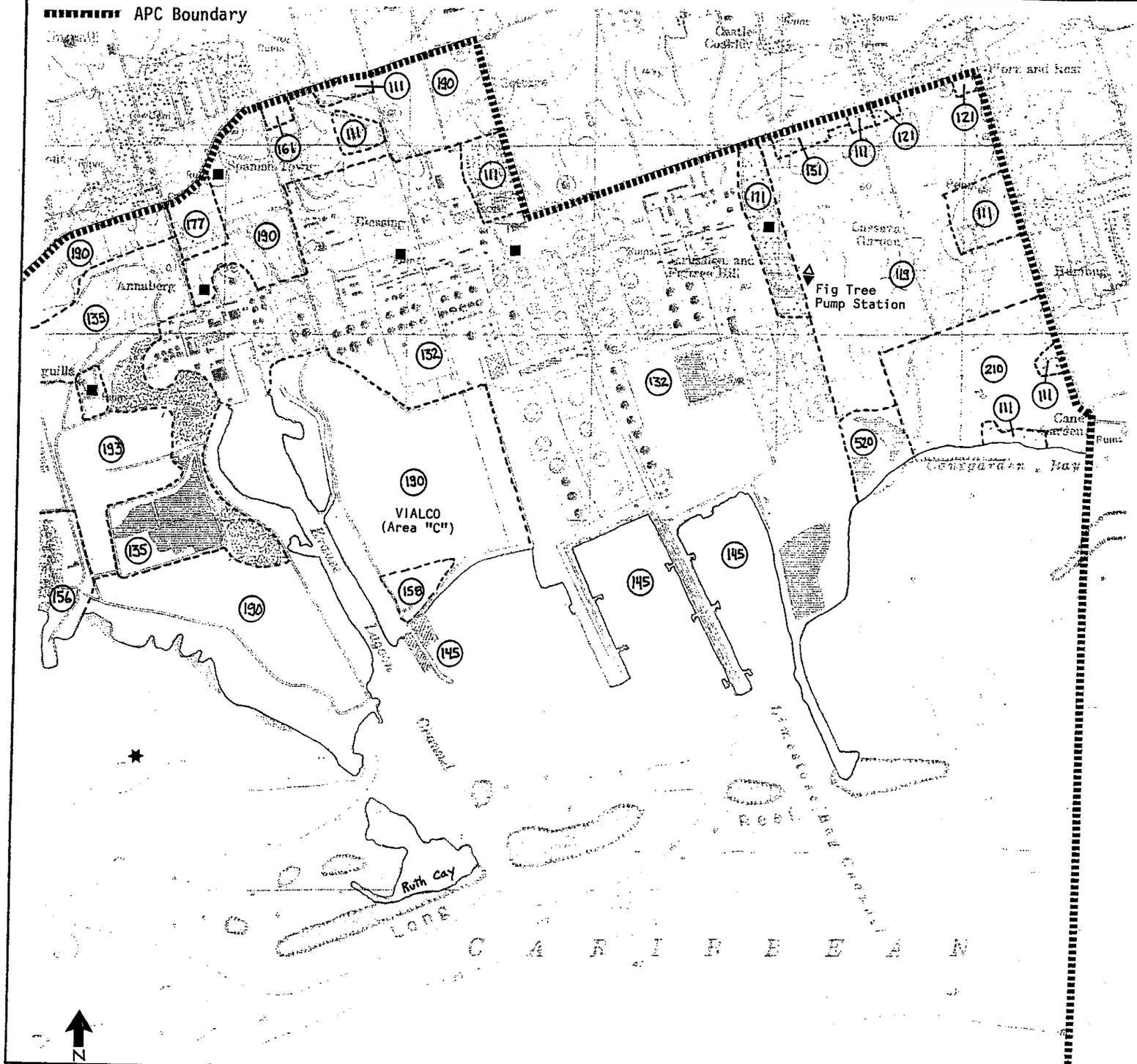
SOUTHSHORE INDUSTRIAL (East)



LAND USE

Residential

- 111 Single unit (low density)
- 119 Cleared for residential development

Commercial

- 121 Retail and commercial

Industrial

- 131 Light industrial/manufacturing
- 132 Heavy industrial
- 135 Industrial tailings & cooling ponds

Transportation

- 145 Port facility

Utilities

- 156 Solid waste disposal
- 158 Proposed power plant
- ▲▼ Pump station (sewage)
- ✱ Sewage outfall

Institution

- 161 Educational facility

Recreational

- 177 Outdoors recreational facility

Others

- 190 Open land
- 193 Land cleared for development
- 210 Cropland/pastureland
- 510 Salt ponds
- ■ Cultural and historical sites

Figure 10b
Land Use within APC (East)
Base map adapted from: USGS, 1982
Island Resources Foundation, 1992

Classification system adapted from: Teytaud, 1981

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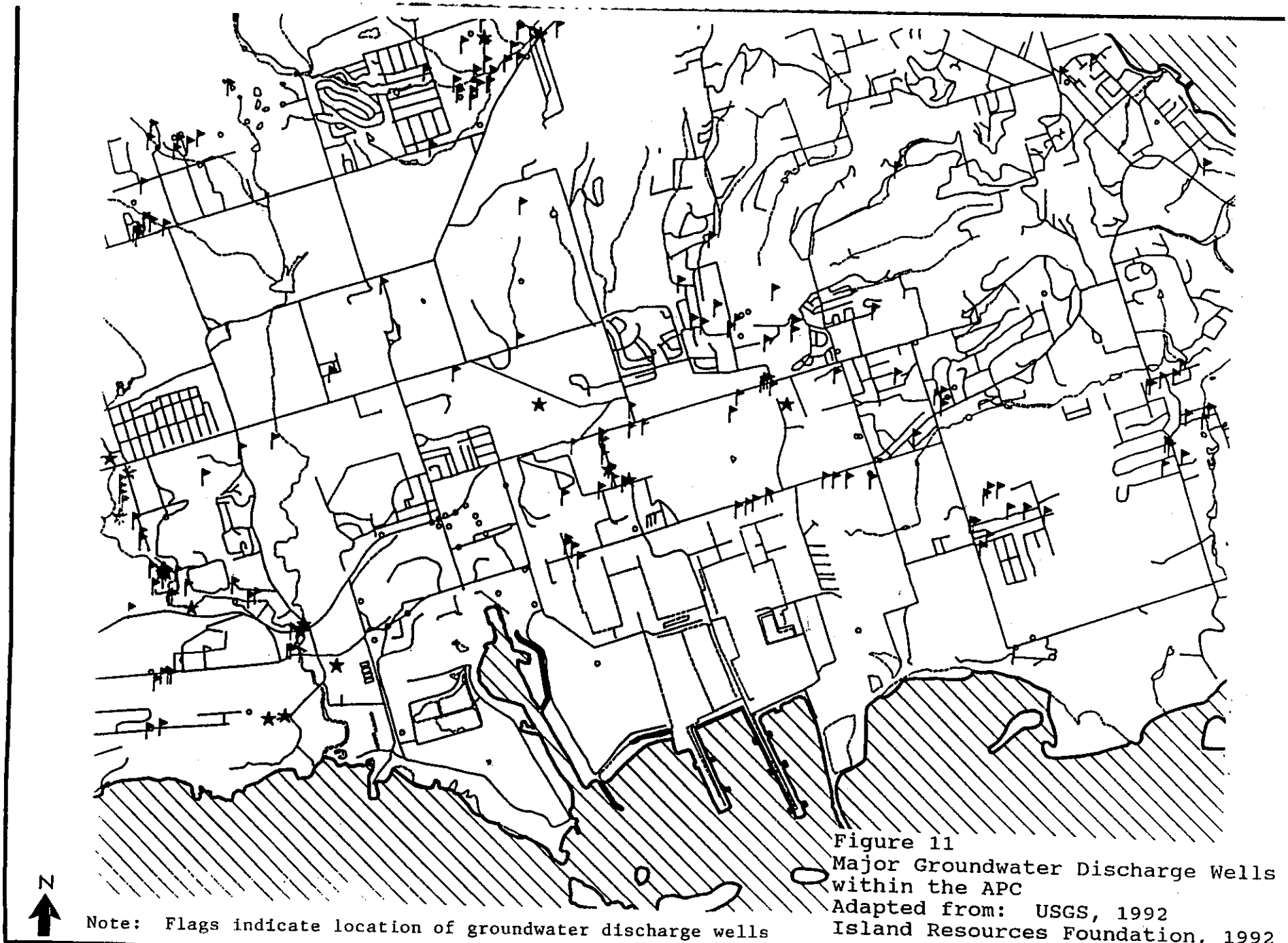
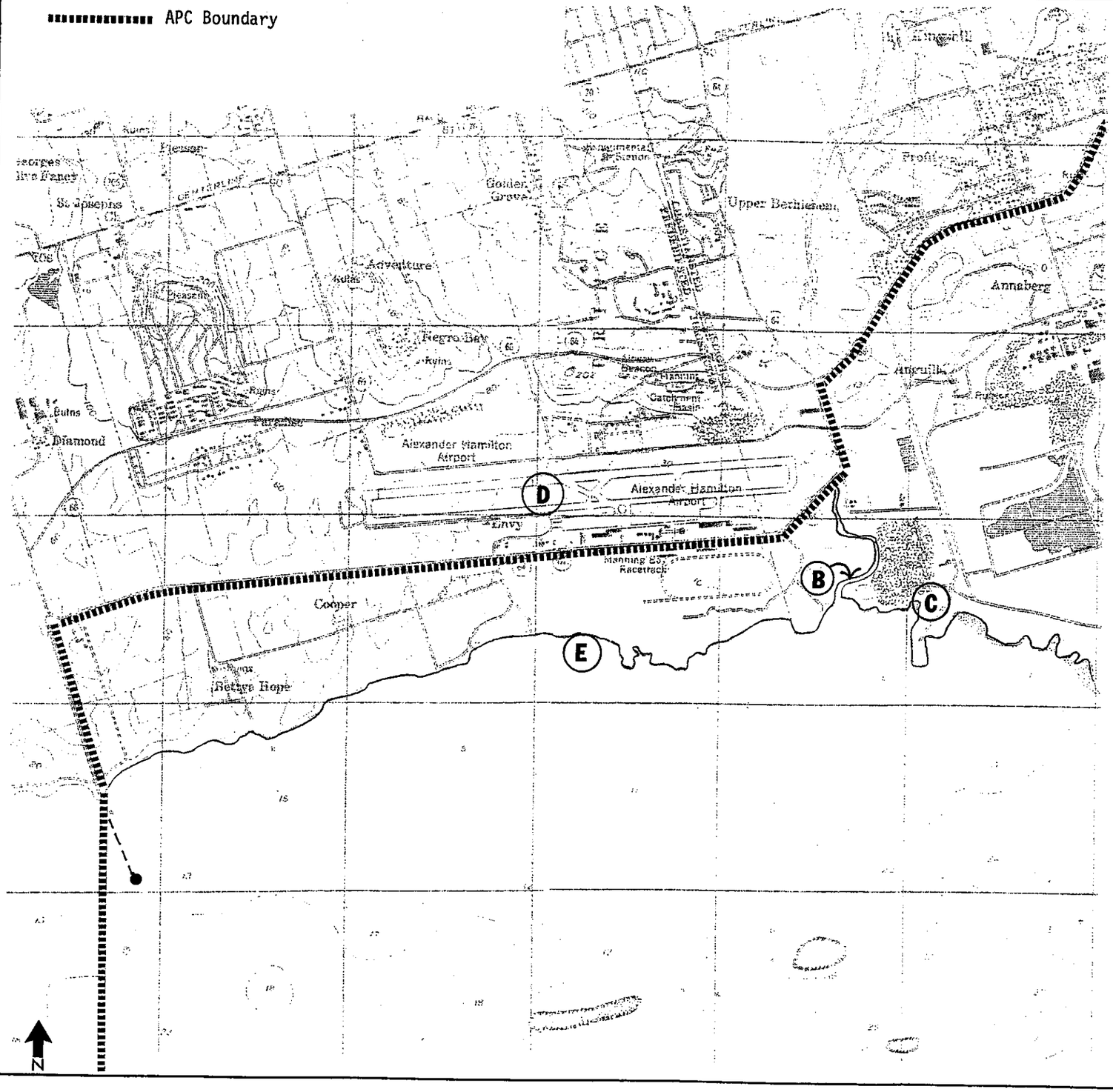


Note: Flags indicate location of groundwater discharge wells

Figure 11
Major Groundwater Discharge Wells within the APC
Adapted from: USGS, 1992
Island Resources Foundation, 1992

SOUTHSHORE INDUSTRIAL (West)

APC Boundary



LAND USE/OPPORTUNITIES AND CONSTRAINTS

- Approximate location of VIRIL outfall (1900' from shoreline)
- (B) Bethlehem Gut - should be given special habitat protection
- (C) Municipal landfill should be relocated; moved away from shoreline in interim
- (D) Stormwater management plan needed for airport; oil/water separators used as necessary
- (E) Manning Bay mangroves - affected by restricted surface runoff as result of development; restore hydrology where possible

Figure 12a
Opportunities and Constraints (West)
Base map adapted from: USGS, 1982
Island Resources Foundation, 1992

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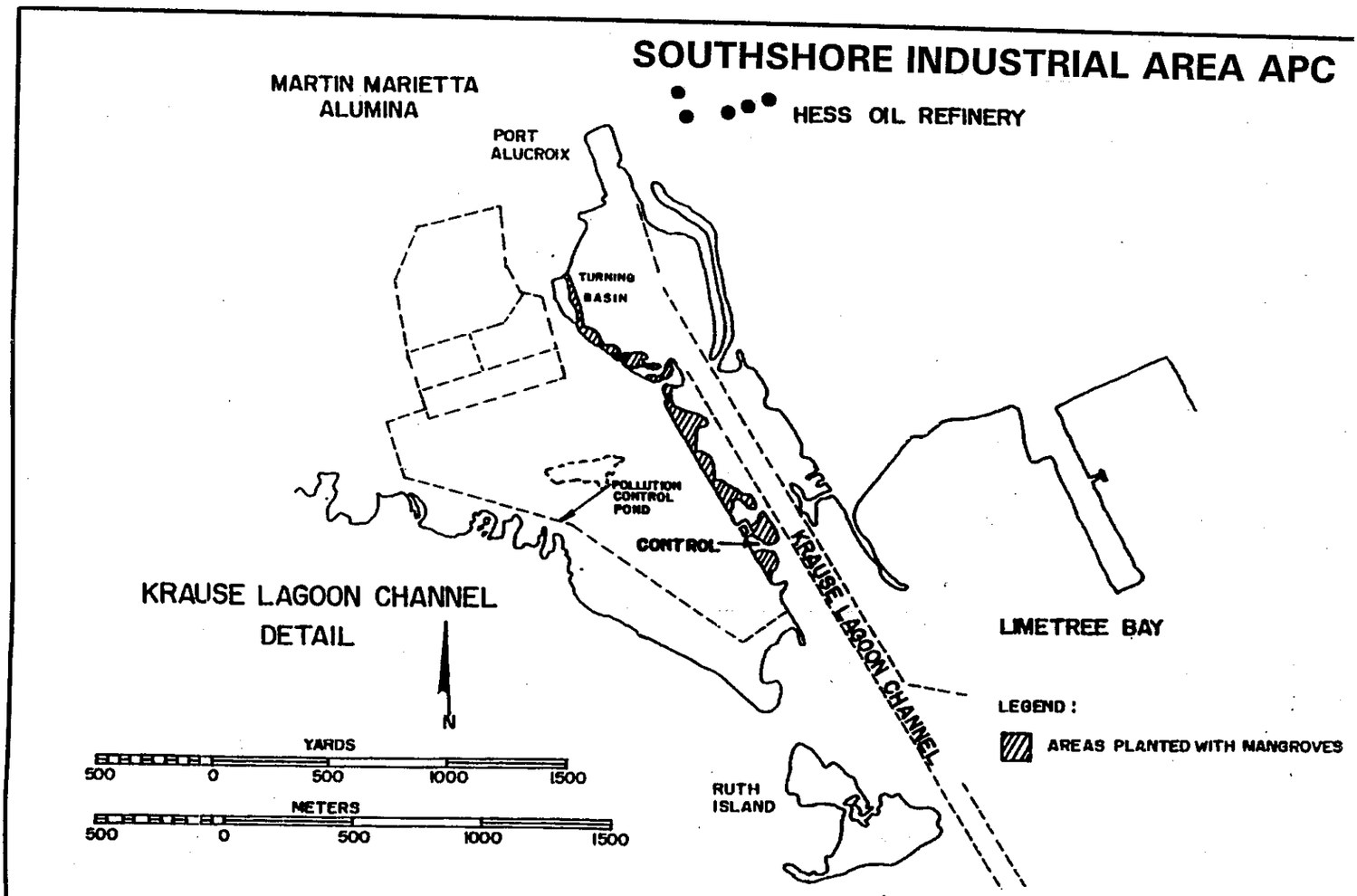

Figure 13
Transplanted Mangroves in
Alucroix Channel, 1978
Adapted from: Lewis & Haines, 1980
Island Resources Foundation, 1992

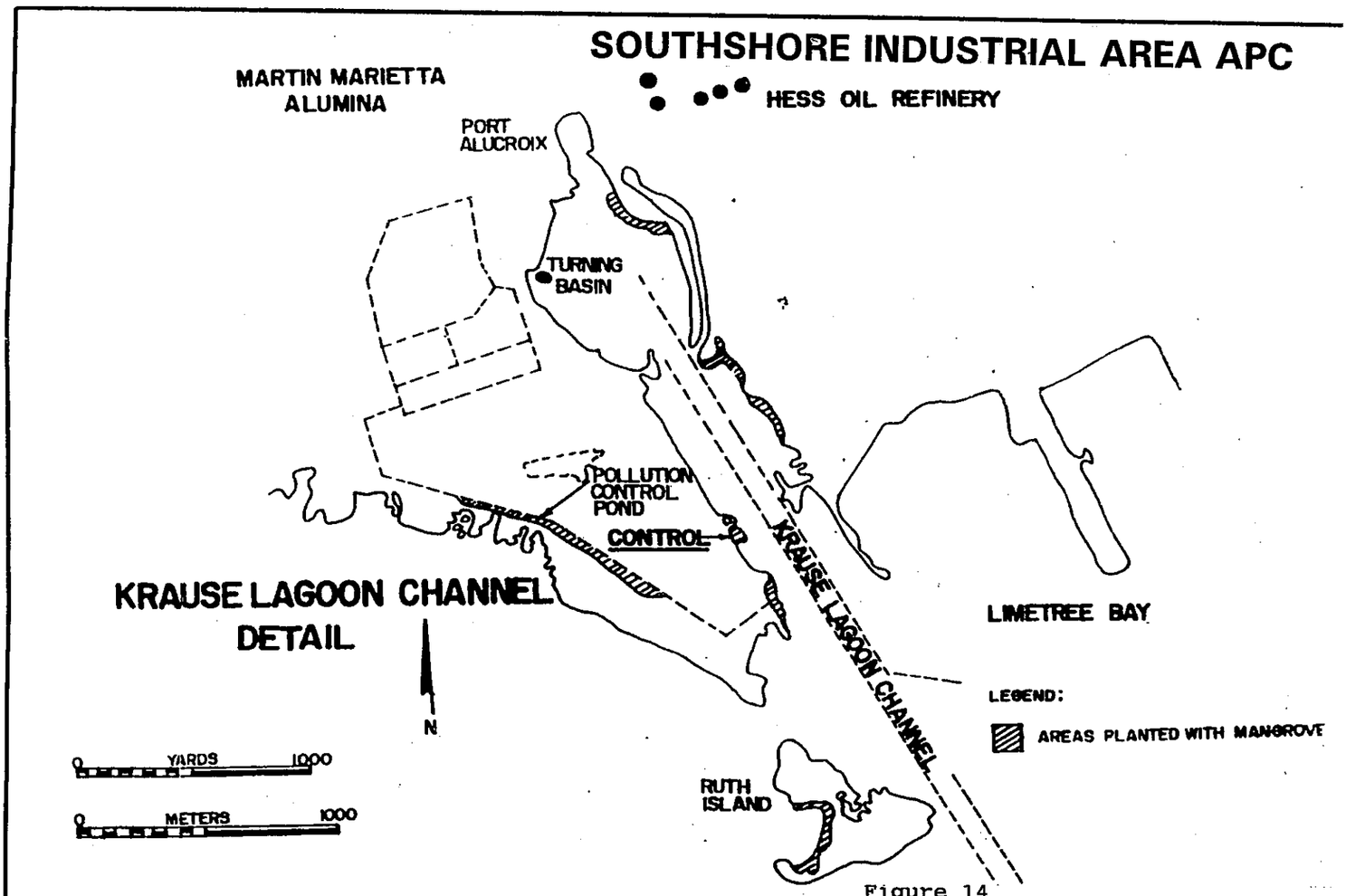

Figure 14
Transplanted Mangroves in
Alucroix Channel, 1979
Adapted from: Lewis & Haines, 1980
Island Resources Foundation, 1992

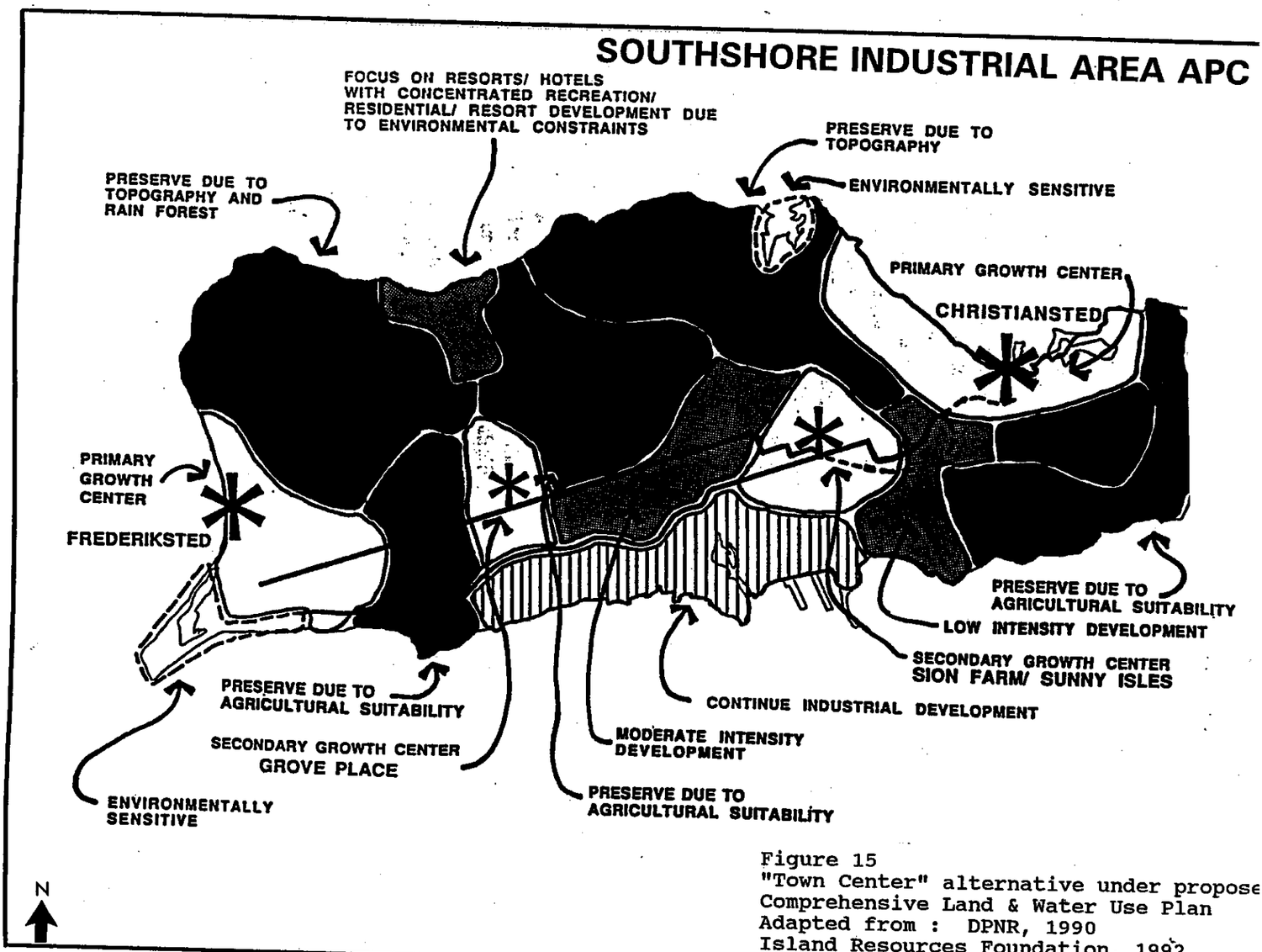

Figure 15
"Town Center" alternative under propose
Comprehensive Land & Water Use Plan
Adapted from : DPNR, 1990
Island Resources Foundation, 1992

SOUTHSHORE INDUSTRIAL AREA APC

U.S. Virgin Island
Zoning Codes

A-1	Agricultural District
A-2	Agricultural District
R-1	Residence Low Density
R-2	Residence Low Density
R-3	Residence Medium Density
R-4	Residence Medium Density
R-5	Residence High Density
B-1	Business Central Business District
B-2	Business Secondary
B-3	Business Scattered
B-4	Business Residential
C-	Commercial
I-1	Industry Heavy
I-2	Industry Light
W-1	Waterfront Pleasure
W-2	Waterfront Commercial-Industrial
P-	Public

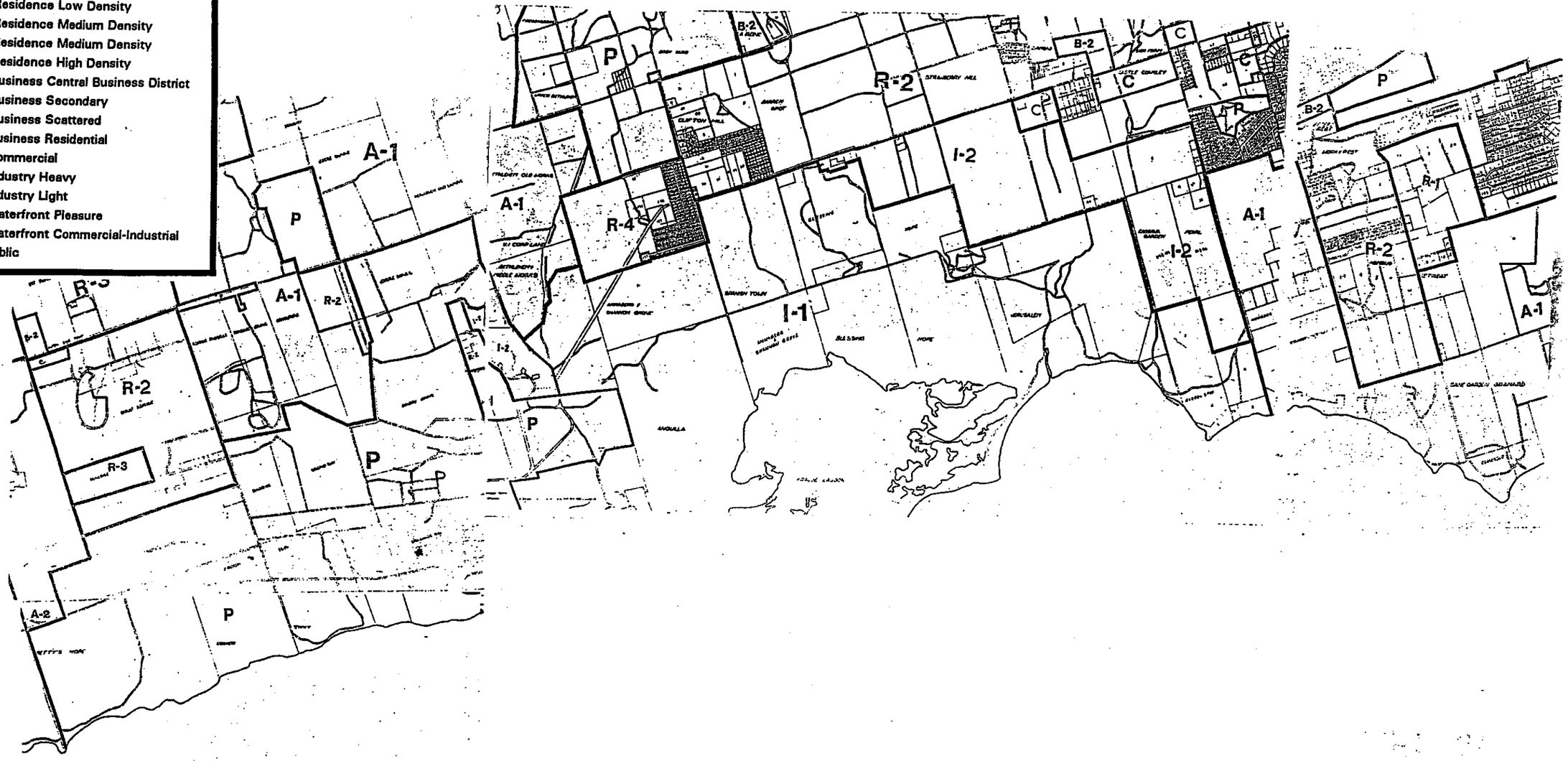

Figure 17
Zoning Map
Adapted from: Real Estate Data, Inc., 1987
Island Resources Foundation, 1993